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NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

# Technical Report No. 32-990

# The Mars 1964-1965 Apparition

C. F. Capen



JET PROPULSION LABORATORY
CALIFORNIA INSTITUTE OF TECHNOLOGY
PASADENA, CALIFORNIA

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# *The Mars 1964-1965 Apparition*

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## PREFACE

This Report represents research conducted at Table Mountain Observatory, Big Pines, California.

## ACKNOWLEDGMENT

Without the dedication, perseverance, and integrity of the Mars patrol observers in procuring solo telescopic observations in a sub-freezing mountain environment in order to obtain as complete an observational coverage as possible, this study of Mars could not be presented. Grateful acknowledgment is here given to James W. Young, JPL, for his talented and critical procedure in producing the many composite images of Mars reproduced in this work. Special credit is due Virginia W. Capen, JPL, for her careful measurements of the planetary images, critical analysis of the tabular data, assistance in arranging the photographs, and rapid typing accuracy of the difficult Latin nomenclature. Ray L. Newburn, JPL, generously reviewed the manuscript for technical content and clarity.

Grateful appreciation goes to Dr. E. Shoemaker, Director, and the staff members of the USGS, Astrogeology Department, Flagstaff, Arizona for the kind permission to use the Gilbert Observatory 30-inch Cassegrain telescope and dark-room facilities, which increased the quality and quantity of the planetary data presented under this cover. Special thanks are due Dr. J. Hall, Director of the Lowell Observatory, for the invitation to use the International Astronomical Union (IAU) Planetary Data Center's new facilities; and to the several staff members of this institution for their technical skills and advice throughout the observational patrol. Four comparison Mars photographs used in this Report were generously furnished by the Lowell Observatory, IAU Planetary Data Center.

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## ABSTRACT

A multicolor photographic and visual patrol of the planet Mars was carried out for an entire terrestrial year that covered the Martian northern hemisphere spring and summer during the 1964–1965 apparition. The spectral range of the photographic program included the ultraviolet, visual, and infrared in seven discrete pass-bands. The nightly visual record was obtained with the aid of six color filters spaced across the visual spectrum. The Mars observing program, observational techniques, and Mars patrol coverage are described. A colorimetry program employing integrated light on color film and color visual records with telescopic apertures greater than 20 inches was accomplished. Good observational coverage was obtained of the *Mariner IV* scan region (110°–200° long.) before, during, and after the photographic contact of July 15, 1965 UT, in an effort to predict and describe atmospheric and surface conditions during encounter. The nightly visual data greatly facilitated the reduction and analysis of the photographic record.

A summary of Martian seasonal events observed from September 1964 to September 1965 is given. Martian polar regions are explored and North Polar Cap regression curves obtained from orange-red and green plate measurements are presented. The north cap dark peripheral melt-band and abnormalities of the Cap are described. South polar hood activity and extent are given. Atmospheric and meteorological observations are thoroughly analyzed. A cloud and haze statistical survey gives percentages of morning and evening limb coverage. A study of afternoon recurrent clouds in the northern hemisphere reveals their positions, seasonal occurrence, and individuality. An atmospheric opacity to green light was discovered to last for a period of about four terrestrial months. "Green haze" may be a by-product of yellow clouds. Data on atmospheric opacity to violet light and "blue-clearing" are given in tabular form. Periods of "blue-clearing" were recorded not only at opposition, but also as early as 160 days before and as late as 130 days after opposition. No intense blue-clearing was observed during the apparition. White area activity is shown to be limited to

## ABSTRACT (Cont'd)

static surface positions. A description of the surface features, seasonal changes, and secular changes observed during the Martian spring and summer completes the apparition analysis.

A daily observation report of surface conditions and atmospheric phenomena, a Mars pictorial atlas consisting of 358 drawings and photographs obtained during the 1964–1965 apparition, and *Mariner IV* photographic data are presented for further study and analysis. The Mars observation log, physical data for observations of Mars for the 1964–1965 apparition, change in Martian longitude vs. Universal Time, and a key map to the Martian surface features are included in the Appendixes as an aid to interpretation of the data.

# I. INTRODUCTION

The 1964–1965 Martian apparition was an aphelic opposition. An apparition is astronomically defined as the duration of useful appearance or observability of a planet. The planet Mars, in the next orbit outside Earth's, requires 687 days to complete its year, or just 43 days short of being twice the terrestrial year. The planet Earth overtakes Mars every 2 years and 50 days on the average. The point of passing is called an opposition because Mars is opposite the Sun relative to the Earth with a celestial longitude difference of 180°. Figure 1 illustrates opposition positions from 1963 through 1978. Every opposition occurs in a different part of the planet's orbit, and the opposition points rotate in a counterclockwise direction around the Sun in a 15-year interval. If the student of Mars is fortunate enough to be born at the proper time in the interval, he may enjoy observing five favorable oppositions. It is only during an 8- to 10-month period which is centered on the opposition date that useful telescopic observations can be acquired. Each apparition gives an opportunity to observe the planet Mars closely only during one or two Martian seasons.

At the beginning of each apparition Mars is observed low in the eastern morning sky, nightly moving away from the Sun, with the preceding-side evening terminator forming a gibbous phase, and with a small but increasing apparent disk diameter. Mars rises higher and higher in the sky each night until near opposition, when it is seen at full phase, with its maximum disk diameter for the given apparition, and it is observable all night. After opposition the planet is observed to settle in the west as it moves toward the Sun, with a morning following-side terminator re-forming a gibbous phase, and with a diminishing disk diameter during the latter part of the apparition (Fig. 2).

Favorable oppositions occur on or about the terrestrial date of August 23 when Mars comes to opposition close to perihelion, with a possible minimum distance from the Earth of about 34.6 million miles and a disk diameter of 25.1 seconds of subtended arc. Unfavorable oppositions occur around February 25 when Mars is at opposition near to aphelion, at which time the minimum distance between the two planets can be no less than about 61 million miles with a disk diameter of only 13″.8 of arc. The relative apparent Martian disk sizes for aphelic through perihelic oppositions 1963–1971 are shown in Fig. 3. The southern hemisphere is always turned toward

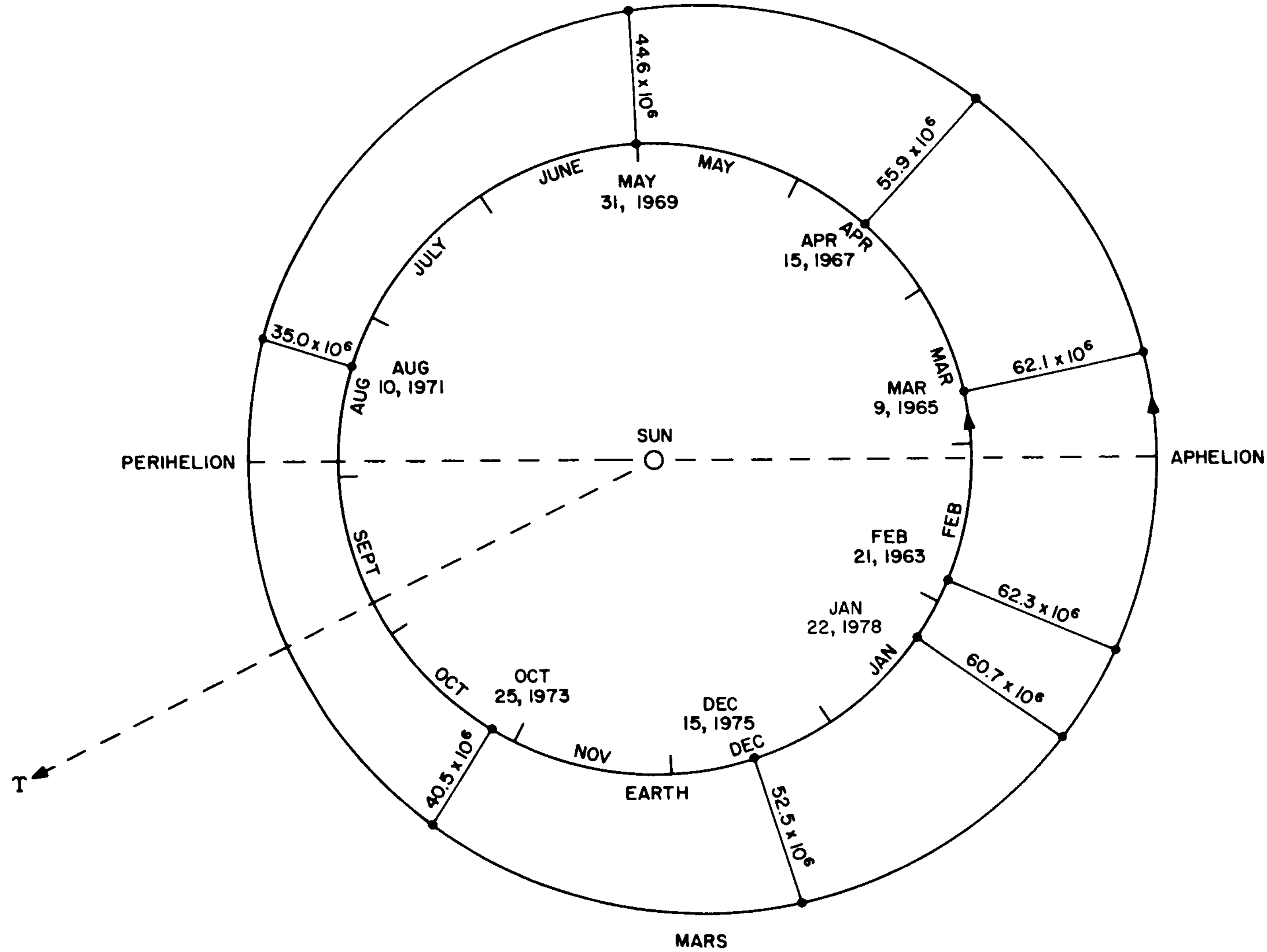



Fig. 1. Heliocentric chart for Earth and Mars, 1963–1978

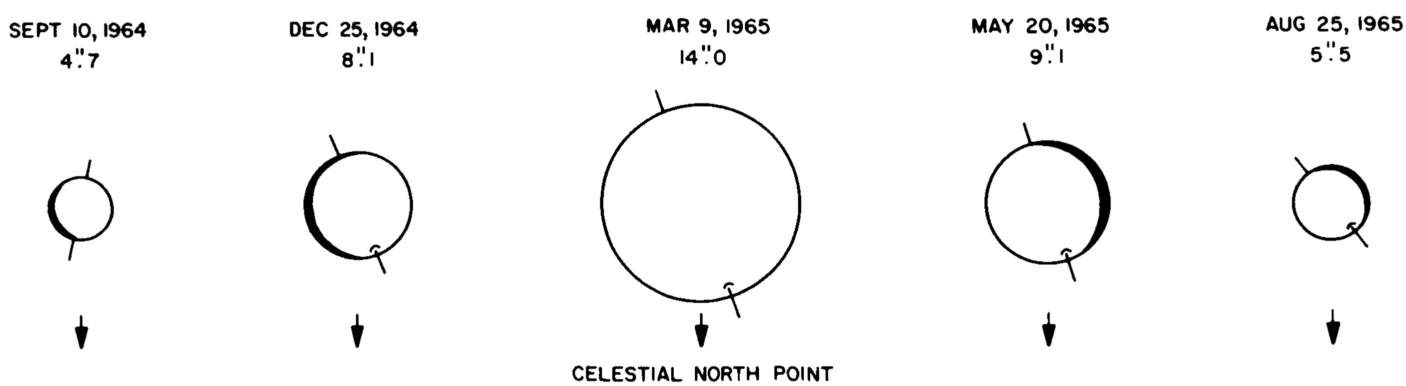



Fig. 2. Apparent disk diameter, phase, and axial position of Mars from the first observation, through opposition, to the last observation of the 1964–1965 apparition

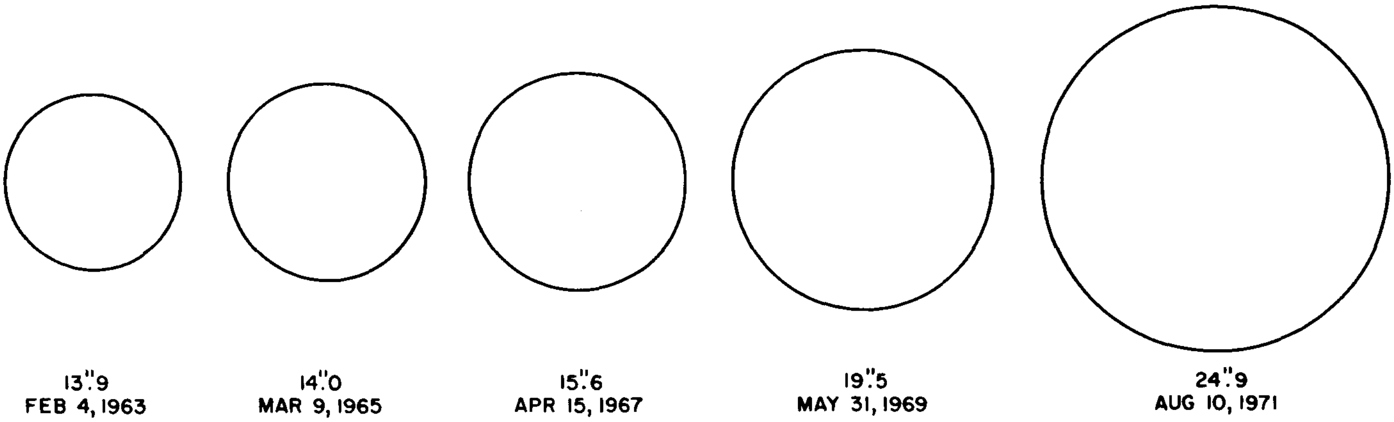



**Fig. 3. Relative apparent Martian disk sizes, in seconds of subtended arc, for aphelic through perihelic oppositions, 1963–1971**

the Earth during the favorable perihelic oppositions; and contrarily, the northern hemisphere is presented to our view during aphelic oppositions.

The rotation period of Mars, or Martian day, is $24^h\ 37^m\ 22\overset{s}{.}6$, just $41^m\ 18\overset{s}{.}5$ longer than the Earth's rotation period. This longer period is equivalent to about 10° retrograde rotation in Martian longitude (refer to Appendix C). To the observer of Mars this means that the planet will appear to back up 10° in longitude each night. Therefore, the apparent longitude retrograde period is about 36 days. Consequently, any given Martian region is observable for an 8- to 10-day period at intervals of about 36 days.

The axes of the planets Mars and Earth are both tilted about 24° from the vertical to their respective orbital planes, which means that they both have four comparable seasons. However, the axis of Mars is directed about 45° from that of the Earth. Alpha Cygni is probably the Martian North Pole Star. Because the axes are tilted in different directions, the Martian seasons are about 90° out of phase, or one season in advance of the Earth season; such that, when observations of Mars are made during terrestrial spring oppositions it will be Martian summer in the northern hemisphere or Martian winter in the southern hemisphere. Similarly: observations during terrestrial summer oppositions will obtain Martian northern hemisphere autumn (southern spring) seasonal data; terrestrial autumn oppositions yield Martian northern hemisphere winter (southern summer) data; and oppositions occurring during terrestrial winter give Martian northern spring (southern autumn) seasonal aspects. The phenomenon of the Martian seasons is particularly important to the collection of data, its study, and interpretation of recorded events. The Martian year is nearly twice that of the Earth, which makes the seasons longer than the Earth's; also, the Martian seasons are unequal because of the rather high orbital eccentricity. Northern spring (southern autumn) is 199 terrestrial days in length. Northern summer (southern winter) equals 182 days. Northern autumn (southern spring) lasts only 146 days. Northern winter (southern summer) lasts a total of 160 days (Ref. 1). The Martian seasonal dates (MD) for the 1964–1965 apparition can be found in Appendix B.

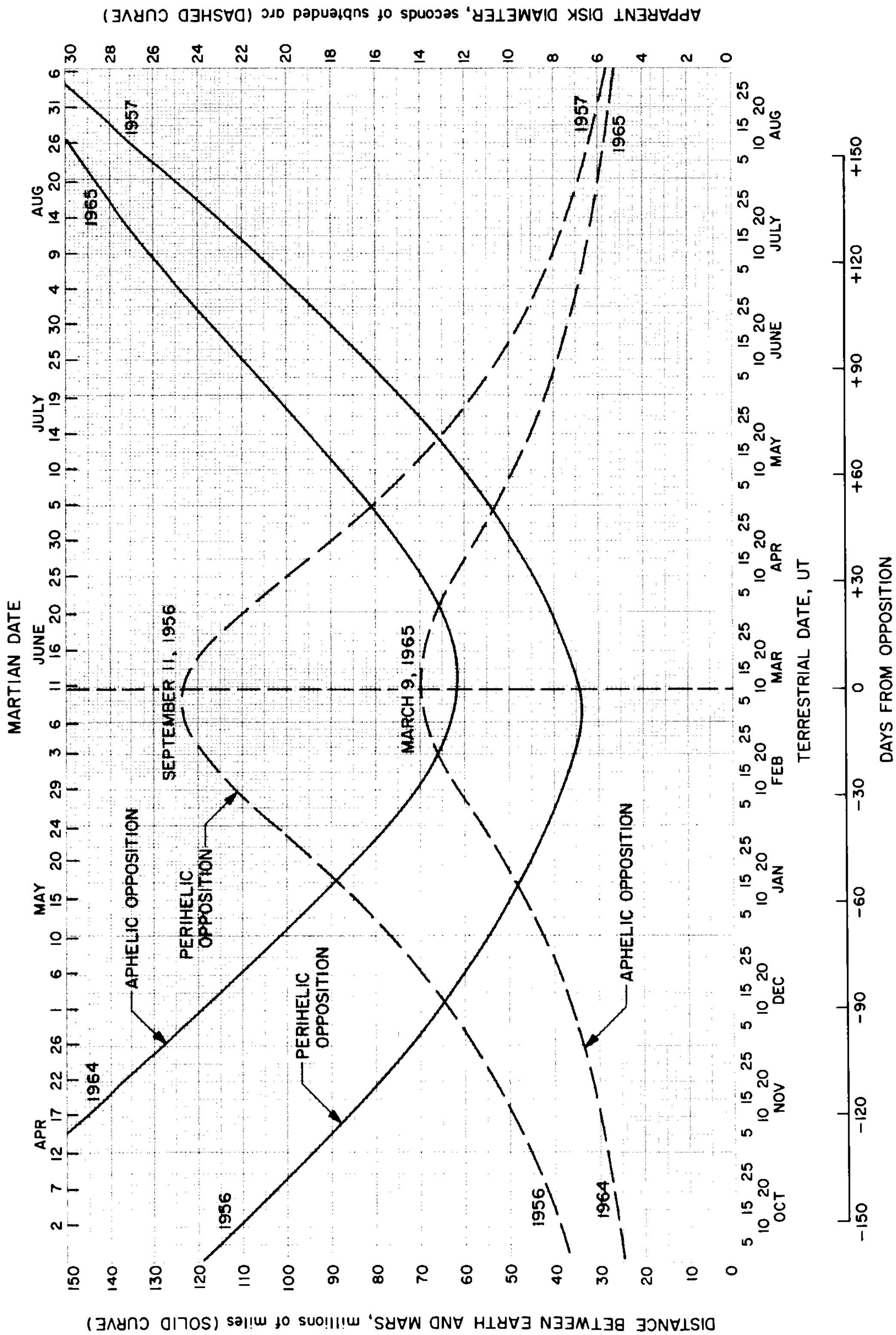



**Fig. 4. Graphical comparison of an aphelic opposition relative to a perihelic opposition**

## II. THE MARS OBSERVING PROGRAM

Aphelic observing conditions are mostly detrimental to the Mars observer. As a consequence, most observational programs in the past have been limited to 3 or 4 months' duration; therefore, much historical data of seasonal activity and areographical features of the northern hemisphere are lacking. Recent observational experience employing modern techniques has shown that any given Martian apparition can be considered to last for at least a 10-month period.

With a Martian disk diameter of only 5″ or 6″ of subtended arc, an observing site having good seeing conditions, and observational patience it is possible to acquire data on general atmospheric conditions, terminator cloud motions, atmospheric opacity studies for the detection of moderate to strong periods of blue-clearing, and polar region phenomena of the Caps' physical conditions and polar hoods. Photographic observation is practical with high-contrast fine-grain emulsions when the disk diameter is greater than 8″ of arc. Fine surface detail can be photographed only on a disk greater than 12″ of arc in diameter. A graphical comparison is made in Fig. 4 between the 1965 aphelion opposition and the 1956 perihelion opposition. From this graph it can be seen that the aphelic curves are flatter than the perihelic ones a few weeks on either side of opposition; and that the aphelic curves are shifted a few days past opposition. The shift indicates that closest approach occurred late, while the opposite is true of the perihelic curves. Both disk diameter dashed curves show that the diameter of Mars is greater than 5″ of arc for about 175 days on either side of opposition, or a total of 350 visual observation nights. The dashed 1965 aphelic curve indicates about 163 useful photographic nights, with a criterion set at 8″ of arc, while the 1956 perihelic curves give a value of 270 possible nights. The dashed curves further indicate that during an aphelion apparition there are only 67 nights above 12″ of arc in diameter for good-resolution photography as compared to 176 good resolution nights during a perihelion apparition. High-resolution photography is possible when the Martian disk is greater than 20″ of arc in diameter, which occurs only during a perihelion apparition for about 74 nights.

A useful ephemeris for physical observations of Mars is compiled by the Table Mountain Observatory staff at the beginning of each Martian apparition from the *American Ephemeris and Nautical Almanac.* The selected data aid observers planning an observational program, observers actively engaged at the telescope, and observers reducing data later. The ephemerides for Mars are given for $0^h$ Universal Time (UT) and reduced or computed in the most useful form for the observer (refer to Appendix B).

## III. THE OBSERVATIONAL TECHNIQUE

The classical method of investigation covers nearly one octave of the visible spectrum from the violet to the deep red. From past empirical observations, it appears that the Martian atmospheric scattering does, indeed, allow observation of different relative atmospheric depths. Violet light records high-level atmospheric phenomena, blue light reveals medium-level cloud activity, green light records ground fog-type clouds and surface frost areas relative to surface features, yellow light records the bright dust-type cloud activity and increases the definition of the dark surface markings, while orange light and red light effectively penetrate the Martian atmosphere and further increase definition of the surface features.

In 1909, Dr. E. C. Slipher of the Lowell Observatory discovered the fact that the photographic disk of Mars appears completely devoid of the dark surface features on blue images relative to yellow images. It was found that surface detail can be perceived in any light of a wavelength greater than 4550A. In light of wavelength shorter than 4550A, surface details are absent from the disk of Mars. The normally uniform, opaque, violet-blue disk occasionally is broken only by bright, impermanent, mobile patches of blue type and white type clouds or temporary limb and terminator haze. The opacity was found to be greater with decreasing wavelength toward the ultraviolet (Ref. 2). The dark surface features can be seen vaguely with ill-defined boundaries in broad blue light and in blue-green light. The obscuring effect was attributed to an unknown violet atmospheric layer.

Pursuing the violet layer study, Dr. Slipher made the surprising discovery that at unpredictable times the Martian atmospheric opacity varied to a point of transparency, allowing surface detail to be photographed in violet light. This atmospheric transparency phenomenon to violet light is called "blue-clearing." The violet opacity variation was not always planet-wide, but was localized at times in different hemispheres. The blue-clearing phenomenon was found to begin rather abruptly at a wavelength of 4550A, with appreciable surface contrast noted as far down as 4250A, which is normally quite opaque. Atmospheric blue-clearing cannot be predicted to date. Little is known about its frequency and strength, and it is uncertain how far down the spectrum toward the ultraviolet the blue-clearing phenomenon can be detected. Consequently, violet and ultraviolet photographic records are obtained during each Martian apparition in an effort to increase our knowledge of the phenomenon and search for a clue from which to form a blue-clearing hypothesis.

Colorimetry of surface features on the small, bright ocher disk of Mars is indeed difficult. With the eye as the receptor, the detection and interpretation of color hues is purely subjective. Only the larger, brighter and highly color-saturated surface details can be detected with telescopic apertures smaller than 20 inches. With instrumental apertures larger than 20 or 24 inches it appears possible to detect, and interpret more accurately, color contrasts of small dark areas, because the larger amount of available light (aperture vs. magnification) increases the level of stimuli to the low sensitivity color-cones within the eye. The larger the aperture, with a given focal ratio and ocular power, the better the quality detection of the hues of small areas and the subtle hues of areas with low color saturation.

The psychophysical color effects during observational colorimetry tend to modify two different adjacent colors. For example, some of the apparent color changes to the visual sense that are color-relation dependent are as follows: When green is contiguous to red or orange, the green appears bluish while the red seems brighter; when green is adjacent to black, the green appears yellowish and the black is tinged reddish; and when black is next to yellow, the black takes on a blueish to violet hue and the yellow becomes lighter. Consequently, tricolor filter cross-checking is essential for visual color determination. The filters employed were so chosen to correspond closely with the primates' three cone pigments responsible for sensing light in the blue (4470A), green (5400A), and red (5770A) portions of the spectrum (Refs. 3, 4).

Visual colorimetry is never successful unless the atmospheric seeing and transparency are above average; a criterion being that the Martian Polar Caps appear perfectly colorless and well defined, or the surface planetary system is well defined. Dark surface features will appear gray or blue-gray or gray-green during good seeing conditions, depending upon the Martian season. During poor seeing the same gray feature will appear yellowish in hue and lighter in shade. The area of a small feature always affects the determination of its true color.

Objective colorimetry is possible by employing color film. The modern improved color film, with its good contrast qualities, is much more color sensitive for the conditions of observation than is the human eye. The exposure time required to obtain a properly exposed Mars image is generally short enough to not alter the color balance; and consequently, color correction filters are unnecessary. Pure colors and color trends can be determined; however, color film cannot be relied upon to differentiate between subtle hues or multiple hues. Color film is an excellent observational tool because of its multilayer structure. Each of the three layers can be separated from one another into broad blue, green, and red pass-bands by the tricolor separation technique. Only one good color image is necessary to record blue atmospheric cloud details, surface whitenings and dark features in green light, and high-contrast fine surface details in red light for study (Ref. 5). Consequently, color film was also employed as a backup to the multicolor spectroscopic plate series during the Mars patrol.

Photographic colorimetry of pure colors in saturated areas is also sometimes successful by comparison of densitometer measurements of suspected areas on multicolor spectroscopic plates, but only if careful calibration is employed. The suspected color or color trend usually has to be known from former observations before selected surface area measurements are practical.

Figure 5 shows the Wratten filters employed in the Mars patrol. During each visual observing period the following Wratten filters were employed: W-47B (4494A) deep violet filter was used for high-level cloud detection and position, atmospheric opacity, and blue-clearing confirmation and extent over the Martian disk. The W-38A (4788A) broad blue filter was employed for determining

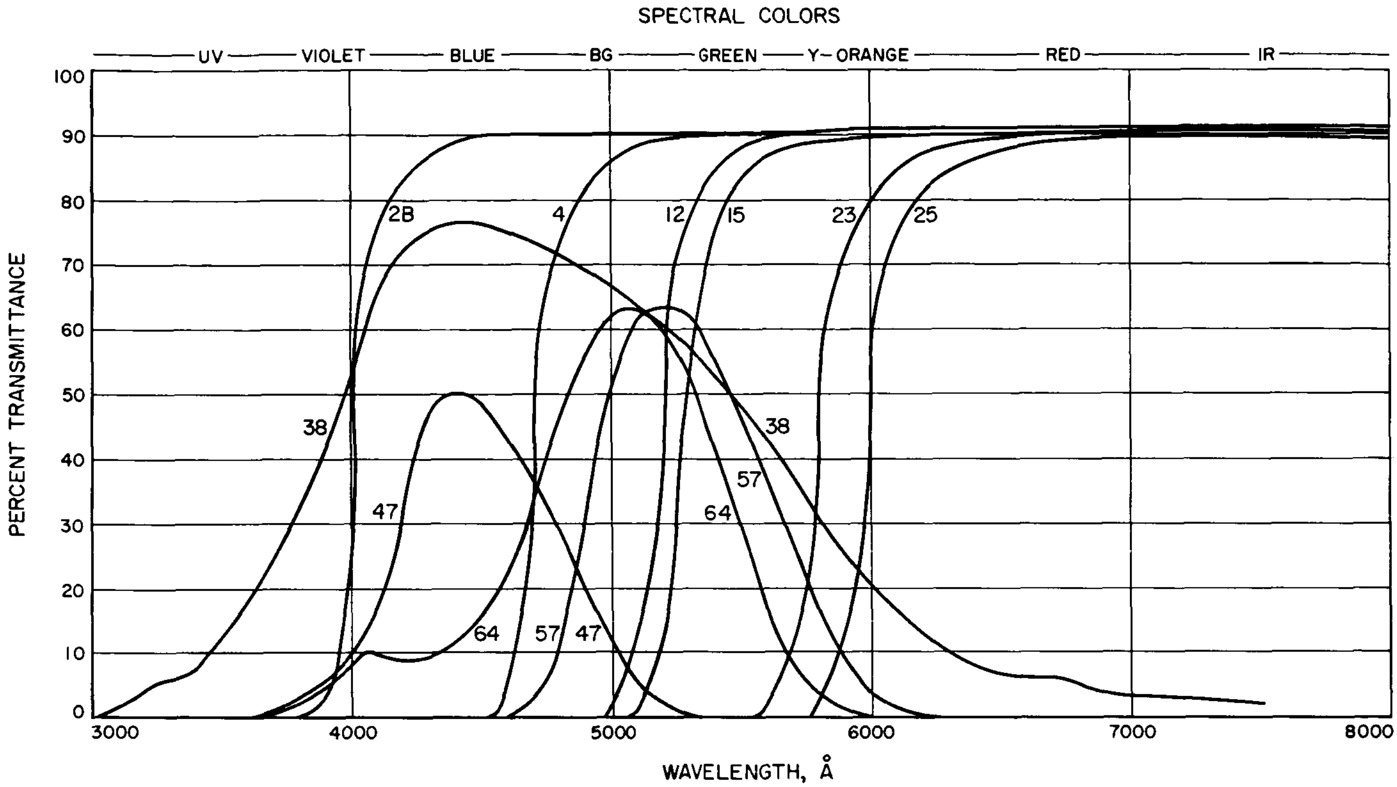



**Fig. 5. Kodak Wratten filter spectral transmittance curves employed in planetary observation**

cloud and limb haze extent and position, atmospheric opacity, and polar hood studies. A W-64 (4973A) blue-green filter was useful in cross-checking low-altitude clouds and haze vs. frost patches. The yellow-green W-57 (5363A) filter defined sharp white boundaries of frosted areas and polar cap periphery by increasing the contrast with the surrounding ocher desert regions, differentiated the low-lying fog-type cloud and surface frost patches from the higher-altitude blue-white type clouds, increased the definition and showed certain canal-like features to be extended, and showed several maria boundaries to be expanded into the adjacent ocher deserts. The W-15 (5792A) yellow and the W-23A (6026A) orange filters were employed to effectively penetrate both the Martian and terrestrial atmospheres, and thereby improve definition of the dark surface features by decreasing the disturbing effects from atmospheric scattering and turbulence (astronomical seeing), as well as increasing the contrast between the dark surface markings and the deserts by darkening the blue-green and blue-gray markings while brightening the ocher deserts. Similarly, the W-25 (6153A) red filter further improved definition of the surface features and was used for cross-checking atmospheric blue-clearing. Wratten tricolor separation filters used for cross-checking colorimetry were the W-47 violet, W-57 green, and W-25 red or W-15 yellow (Refs. 4, 6).

The spectral range of the photographic program was expanded by the addition of the infrared and the ultraviolet at each end of the visual spectrum. Figure 6 shows the Schott filter spectral transmittance curves relative to the Kodak spectroscopic emulsion class sensitivity curves that were employed in the nightly photographic patrol. The filter and plate combinations used are as follows: The III-O, UG-11 was used for recording in ultraviolet. The III-O, Wratten 47B was employed for violet light observations. The III-O, GG-13 (−UV) or the IV-O, GG-13 was used for photographing a broad blue region. The III-G, GG-14 or the IV-G, GG-14 was employed for photography in green light. The III-F, OG-2, or IV-F, OG-2 was used in the yellow-orange region. The IV-E, RG-1 combination was used for recording in red light. And the IV-N, RG-10 was employed to obtain the infrared record. The emulsion type giving the highest contrast, finest grain, and slowest speed was employed, according to the dictates of the astronomical seeing.

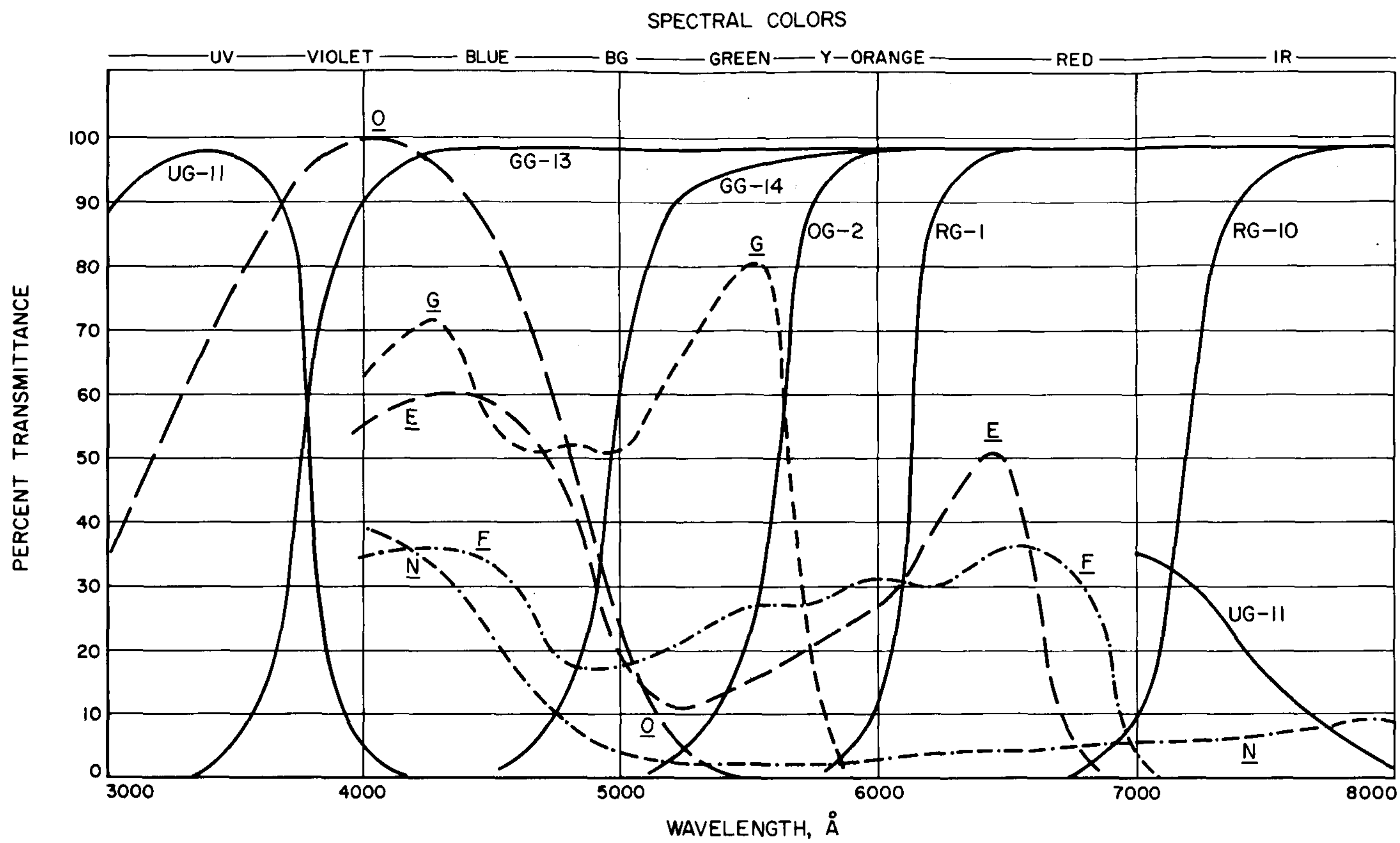
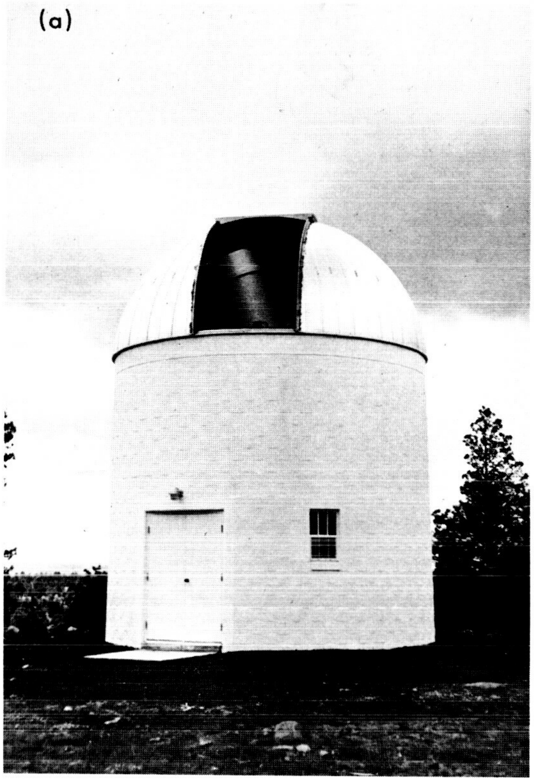


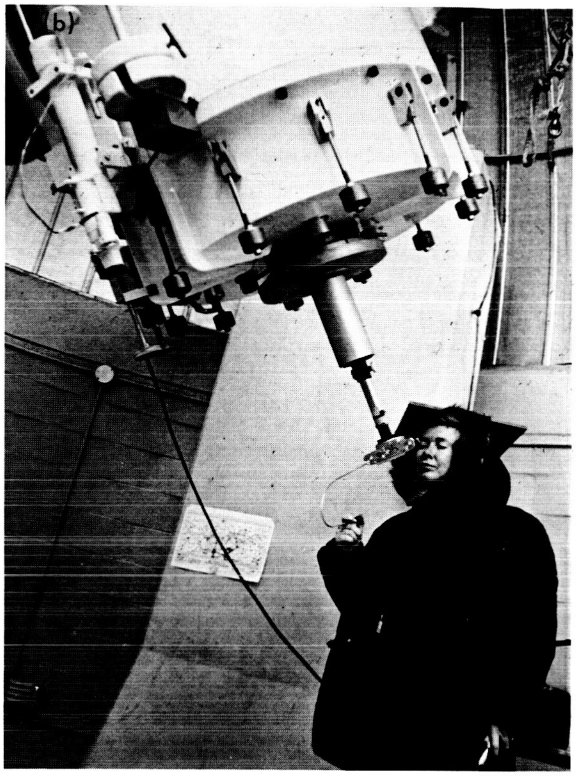

**Fig. 6. Schott filter transmittance curves versus Kodak spectroscopic emulsion class sensitivity curves**

The JPL Table Mountain Observatory 16-inch Cassegrain *f*/20 reflecting telescope and the U. S. Geological Survey (USGS) Astrogeology Gilbert Observatory 30-inch Cassegrain *f*/15 telescope were the instruments employed for observations of Mars. A quartz −3× amplifying lens was used to increase the photographic image scale from 25.″8/mm to 8.″6/mm on the 16-inch reflector for improved plate definition, and a crown type −4× Barlow amplifying lens was used on the 30-inch reflector to obtain a 4.″5/mm scale.

## IV. 1964–1965 MARS PATROL COVERAGE

Observation of Mars during the 1964–1965 aphelic apparition began late in the morning on September 11, 1964, when the disk diameter was only 4.″7 of subtended arc with the JPL Table Mountain Observatory 16-inch Cassegrain reflector (Fig. 7), and ended on the evening of October 12, 1965, with a disk diameter of 4.″9 of arc. Observation of Mars with the USGS Gilbert Observatory 30-inch Cassegrain reflector (Fig. 7) was initiated on the Martian opposition date of March 9, 1965, with the kind permission of Dr. E. Shoemaker, USGS, Astrogeology Department, Flagstaff, Arizona, and was terminated after the *Mariner IV* spacecraft flyby of Mars on the evening of July 21, 1965. Not only did the use of the bigger 30-inch aperture give better resolution, but the different location and terrain gave an out-of-phase weather pattern, which produced more observations with better time coverage. Excellent colorimetry and fine surface detail observations were obtained on two occasions with





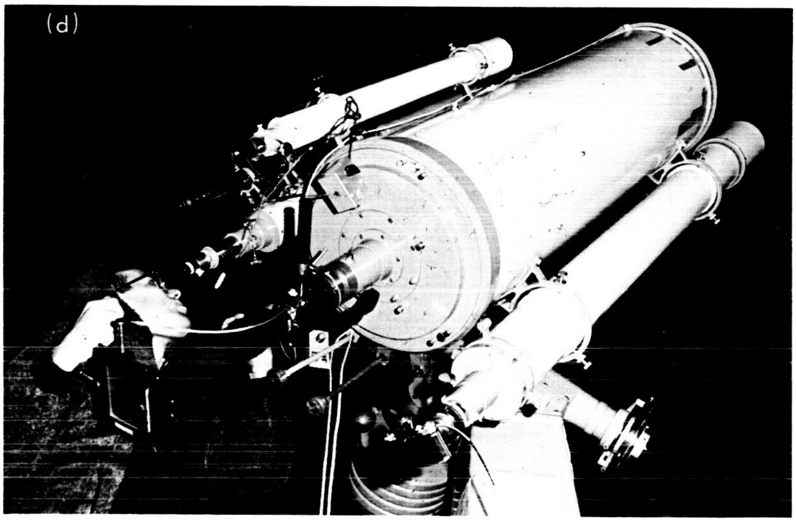



**Fig. 7. Observatories and instruments employed during the 1964–1965 Mars patrol: A) USGS Astrogeology Gilbert Observatory, Anderson Mesa, Flagstaff, Arizona; B) Observer Virginia Capen photographing the planet Mars with the Gilbert Observatory 30-inch Cassegrain telescope; C) JPL Table Mountain Observatory, Big Pines, California, photographed at night in last-quarter-phase moonlight (note star trails of Big Dipper, upper right); D) Observer James Young setting the Table Mountain Observatory 16-inch Cassegrain telescope for plate camera photography**

the Kitt Peak Observatory 84-inch reflector. The apparent disk diameters, aspect of the phases, and axial positions for the 1964–1965 apparition are shown in Fig. 2.

Regardless of the poor intrinsic observational conditions and terrestrial weather encountered during the Mars patrol, the Mars 1964–1965 aphelic apparition was probably given the greatest attention in the observational history of Mars, because of the interest in the *Mariner IV* space mission. The *Mariner IV* scan longitudes were well observed each month from February through July. Quality black and white and color photographs and visual drawings yielded enough information to construct a photovisual map of Mars 200° wide in longitude, centered over the *Mariner IV* scan region.

The fast moving space-age demands immediate observational results, for which the classic astronomer is not geared; consequently, a daily written observation record was kept during the entire apparition in an effort to discern and predict atmospheric trends and surface conditions during the *Mariner IV* encounter.

The Mars patrol observers, Virginia W. Capen, James W. Young, and the writer, planned the observation periods, prepared cameras and filters for observation, performed the telescopic observations every observable night, seven nights per week, and daily performed film and plate processing, printing, compositing, and data reduction (Fig. 8). The observers traveled between the Table Mountain Observatory and the Gilbert Astrogeology Observatory in order to take advantage of local good weather and available telescope time.

The visual written record was made, usually before and again after the photographic patrol, in order to get the greatest longitude coverage. Visual observation was filter-aided by observing disk features in six pass-bands from deep violet, through the visual spectrum, to deep red light. Trifilter cross-checking was used on many individual areas. Photographic records were obtained in defined pass-bands across the spectrum covering a spectral range from 3000 to 8700A. The best of each night's "astronomical seeing" was used for photography. Also, an uncalibrated colorimetry program employing integrated light on color film and color visual records with telescopic apertures greater than 20 inches was accomplished.

The Mars patrol covered the planet for six Martian months, from March (late northern winter) into Martian September (end of northern summer) with a total of 926 separate observations: 292 multicolor spectroscopic plates containing approximately 13,000 images were made at the TMO 16-inch Cassegrain instrument with a scale of 8.″6/mm; 246 multicolor spectroscopic film records containing about 2,450 images were made with the AG 30-inch Cassegrain telescope with a scale of

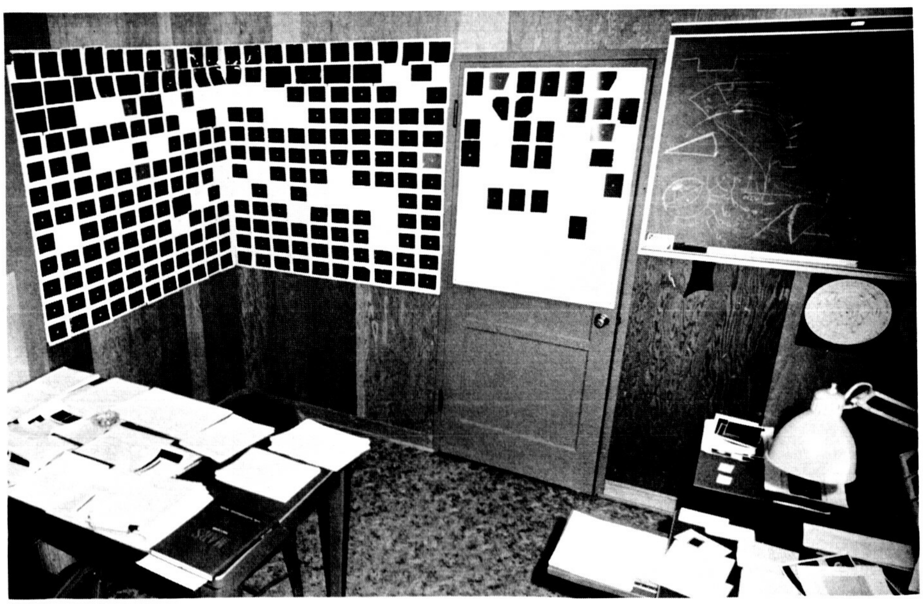


**Fig. 8. Photographic "study-boards"; the reduction of large quantities of independent and related data from hundreds of photographic images is facilitated by reference to these boards, arranged in a chronological sequence**

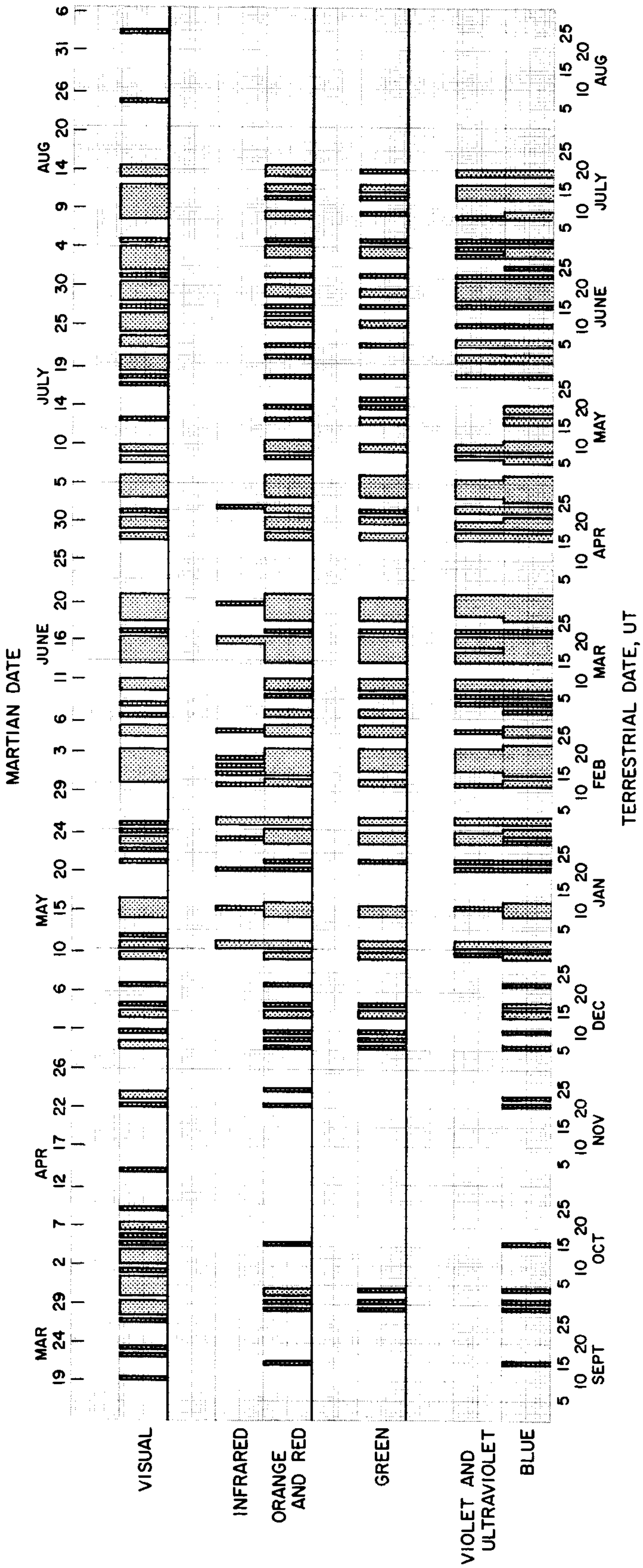



**Fig. 9. Mars patrol observational coverage, 1964–1965**

about 4″.5/mm or with the TMO 16-inch reflector having a scale of 6″.4/mm; 65 color films containing 650 images were exposed with the aid of the above two reflecting telescopes; 321 separate filter-aided visual observations were obtained during the apparition. Also, several photographs taken by R. Schorn (JPL) with the McDonald 82-inch reflector were used to fill in record gaps in May, June, and July.

Observational coverage relative to the terrestrial and Martian date is shown in Fig. 9. The observations are grouped into four chief categories: ultraviolet, violet, and blue light observations; green light observations; infrared, red, and orange light observations; and visual observations. Many terrestrial storm gaps are obvious in the chart. Appendix A lists a complete Mars observation log for the 1964–1965 apparition.

## V. NOMENCLATURE AND ABBREVIATIONS

Figure 10 describes the orientation and nomenclature of the Martian disk as used in this Report.

The photographs, drawings, maps, and daily observation descriptions are orientated to an inverted telescopic Martian disk, where the top is south, the bottom is north, the right side is the following or morning limb, and the left side is the preceding or evening limb.

The planetary rotation is from west to east.

The **terminator** is the line where the daylight ends and the darkness of night begins. The terminator phase (defect of illumination) is given in degrees to define how much of the geometrical visual Martian disk is in darkness. The evening or sunset terminator appears on the preceding limb of the disk before opposition. Close to the date of opposition there is no apparent phase; and consequently, there is no terminator seen by the terrestrial observer. After opposition the terminator becomes the morning or sunrise line on the following limb of the Martian disk.

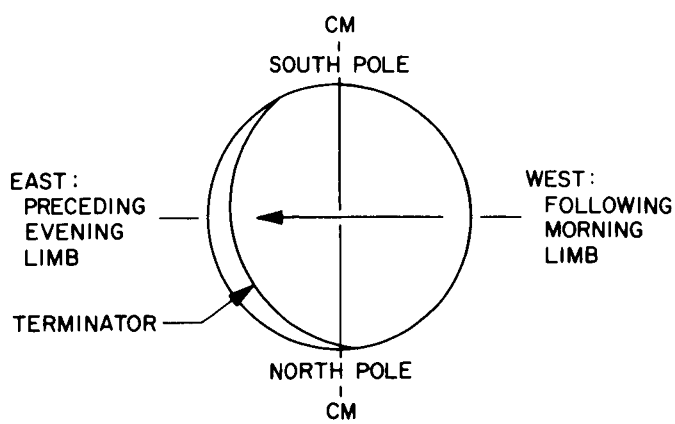



**Fig. 10. Mars disk orientation and nomenclature used in this Report**

The **Central Meridian** (CM) is an imaginary line passing through the planetary poles that bisects the planetary disk, and is used by the astronomer to define what longitudes are present on the planetary disk during an observation.

Descriptive colorimetry defines blue-green as a different hue from green-blue. In the former case blue-green has a blue tint, while in the latter green-blue is stronger in the green. This method of describing hues is followed by the author.

**TD** indicates the terrestrial date. The terrestrial date is written with the day number following the month name; i.e., April 1 TD, in order to avoid confusion with the Martian seasonal date.

**MD** indicates the Martian date. The Martian seasonal date is based on the position of the Sun as seen from the planet Mars, spring in the northern hemisphere beginning as the Sun crosses the Martian equator going north. The Martian date is written with the day number preceding the month name, e.g., 20 March MD, in order to differentiate the Martian seasonal date from the terrestrial observation date.

The International Astronomical Union (IAU) new nomenclature of Mars has been used where possible for the identification of gross features; however, the IAU map is not adequate for fine surface details with which the serious student of Mars is concerned. The 1954 Association of Lunar and Planetary Observers (ALPO) map of Mars and the 1956 map of Mars by S. Ebisawa, which is an updated version of E. M. Antoniadi's 1929 map, have been employed for efficient nomenclature of small details. It must be understood that the "areographic descriptive" terms are similar to the "selenographic descriptive" terms that originated in the eighteenth and nineteenth centuries when nothing was known about the actual surface physical conditions. They should not be taken literally but rather as referring to a characteristic surface feature. The following abbreviations are in standard use on maps of Mars:

**canal** Canali or canal-like feature. A canal is a fine linear surface feature believed to be composed of smaller irregular dark fragments, each fragment close to or below the telescopic resolution.

**desert** A bright ocher surface area.

**D** Depressio, a depression.

**F** Fons, a spring or oasis, usually a small circular dark area located at a junction of canals.

**FR** Fretum, a strait.

**I, IN** Insula, an island or small ocher area.

**L** Lacus, a lake usually found at an oasis position.

**M** Mare, a sea or gross dark surface feature.

**N** Nodus, node, nodule, knot, swelling, a concentration similar to a Lacus.

**Nix** Frost, snow, or a gray-white area.

**P** Palus, a swamp or medium size dark area.

**PR** Promontorium, a cape.

**R** Regio, a light ocher desert region.

**S** Sinus, a gulf or dark surface feature.

**ca.** Center-of-area position for circular frost or cloud formations, used to define a position of a feature when its boundary is symmetrical or fairly circular. (An amorphous-shaped feature has an irregular, formless or diffuse outline, and, as a consequence, its north–south and east-west boundary positions are approximately given.)

**region** Several surface areas or a gross area, e.g., Tempe–Arcadia–Amazonis region.

**area** A surface area or a small surface feature, e.g., the Nix Tanaica area.

**KP 7** Kitt Peak National Observatory 84-inch Cassegrain telescope observation record number.

**AG 10** Astrogeology USGS 30-inch Cassegrain telescope observation record number.

**TMO 3016 (or 3016)** Table Mountain Observatory 16-inch Cassegrain observation record number.

**PH** Polar haze or hood.

**MH** Morning haze.

**EH** Evening haze.

**MC** Morning cloud.

**EC** Evening cloud.

**CB** Cloud band.

Photographs are identified according to the standard IAU nomenclature, where the year, the month, the day, and the filter color are given in order, as well as the Central Meridian (CM), the JPL observation number, type of image print, and the Martian date, for example,

65 03 21 CI (1965 March 21, color integrated light.)

CM287° 4107 (Central Meridian 287°, TMO observation number 4107.)

M MD16June (Multiple image, Martian date 16 June.)

The color filter pass-bands are designated as follows:

| Abbreviation | Color | Emulsion class | Filter | Transmittance cut-off at 10%, Å |
|---|---|---|---|---|
| *UV* | Ultraviolet | O | UG-11 | 3000–3925 |
| *V* | Violet | O | W-47B | 3950–4750 |
| *B* | Blue | O | GG-13 | 3600–5150 |
| *BG* | Blue-green | Visual | W-64 | 4050–5650 |
| *G* | Green | G | GG-14 | 4600–5800 |
| *YG* | Yellow-green | G | W-57 | 4800–5900 |
| *Y* | Yellow | Visual | W-15 | 5200–8000 |
| *O* | Orange | F | OG-2 | 5350–6925 |
| *R* | Red | E | RG-1 | 6000–6700 |
| *IR* | Infrared | N | RG-10 | 7000–8950 |

**I** Integrated light.

**CI** Color integrated light minus UV.

**CB** Color film blue layer separation (W-47B).

**CG** Color film green layer separation (W-61).

**CR** Color film red layer separation (W-25 or 29).

Types of image prints are designated as follows:

**S** Single image.

**M** Multiple or composite image.

**D** Visual telescopic drawing or drawing from a photograph.

## VI. MARTIAN SEASONAL EVENTS OBSERVED FROM SEPTEMBER 1964 TO SEPTEMBER 1965

The observed apparition covered six Martian months during the Martian spring and summer seasons. Following is an account giving the prevalent observed seasonal surface changes and atmospheric phenomena. The described weekly to monthly changes may be seen in Sec. XI; whereas, the daily events leading up to and during the described gross changes can be found in Sec. X.

September 1964 observations of the Martian disk subtending a modest 4.7 seconds of arc revealed only the gross dark surface features, much sunrise limb haze, a south polar hood, a large, clear North Cap, and a terminator cloud projection was followed through the end of the month. A general atmospheric clearing was noted toward the end of the month, with an associated weak to moderate blue-clearing that lasted for thirteen days until October 8. The corresponding Martian seasonal dates were in the latter part of March, about the time of the spring equinox.

In October 1964, photography in yellow and blue light and color film integrated light got off to a good start to augment the visual observations on a Martian disk 5 seconds in diameter. The October and November observations revealed finer surface detail recognition, the formation and darkening of the north polar peripheral melt band, and extensive southern limb haze and a south polar hood. No polar hood was seen over the large, bright North Cap. A weak blue-clearing was detected from October 1 through October 7. The corresponding Martian dates were in early April.

During the months of December and January the planetary disk diameter increased from 7″ to 11″ of arc; consequently, photographic observation expanded into using spectroscopic film and plates employing seven defined spectral pass-bands. A normal seasonal polar and atmospheric activity was observed. A south polar hood and morning limb and evening terminator clouds were noted. The North Cap was clear and sharp and continued its spring melting phase with a rather weak contiguous peripheral band. Two weak periods of atmospheric blue-clearing were noted in December. The Hellas appeared white above the dark Syrtis Major, and a slight equatorial morning limb frosting was detected. The maria generally appeared a dark gray to dark brown shade. The exception was the north tip of the Syrtis Major which was a dark blue-green color. Low-contrast dark surface markings were detected in the Tempe–Arcadia–Amazonis deserts.

February observations recorded a rapidly shrinking North Cap; only a moderate-contrast north cap peripheral band; a decreasing south polar hood; increasing atmospheric blue cloud activity; no atmospheric blue-clearing; the formation of white frost patches on the high desert plateaux; and the late Martian spring season surface changes of color, maria broadening, initial increase in contrast of canal-like features, and oases darkening. A planet-wide atmospheric opacity to green light was discovered during February in longitudes 90°–200°, covering the Arcadia, Amazonis, Trivium, and Elysium regions. An evening terminator cloud covering the Trivium–Elysium area dissipated leaving the Elysium white and as bright as the North Cap.

March yielded many high-quality observations during Martian June of the darkening surface features and increased atmospheric activity. The white North Cap continued its maximum melting rate until the latter part of March (Martian June) when it ceased its regression and increased its diameter by about 2 degrees. Many recurrent clouds were evident over defined surface areas. A general weak blue-clearing was detected but not confirmed photographically on March 30 and 31. The February "green-haze" was still present, but showed a clearing trend. Many frost patches were observed on the sunset and sunrise limbs, and even through high noon on the Elysium. On the night of March 30, clouds put on a remarkable, bright display over the Elysium. The Nodus Laocoontis was an extremely green color.

Observation was not possible the first two weeks of April because of a large West Coast snow storm that brought snow to depths of 8 to 10 feet. The latter part of April gave above-average seeing conditions, especially at Flagstaff, Arizona; and consequently, many high-quality observations were acquired showing fine surface structure. It is unusual to obtain such fine canal-like surface detail during aphelic oppositions. The atmospheric visual cloud activity reached its maximum during the first part of this Martian summer. Likewise, surface contrast of all major dark features and fine details reached their maximum contrast. The arctic region cleared of haze and the North Cap once again started its summer melting rate, showing an irregular, moderately dark periphery, two Cap projections, and a dark rift. The south polar region appeared free of clouds and haze, except for a weak evening limb haze. Recurrent cloud activity was still evident over given surface areas. There were two periods when the atmosphere appeared extremely clear and blue-clearing was observed. Frosted areas were increasing and cloud activity showed a slight decline during the end of April. Evidence of the "green-haze" in longitudes 80° to 260° died out during this month. The northern maria and oases expanded in size and reached their maximum contrast and coloration. The Martian disk was a patchwork of fine canal structure. Green light showed all dark surface details as seasonally swollen features. Many excellent photographs were secured during this observation period.

The surface features continued to darken and broaden at a slow rate in May. Much cloudiness and haze still persisted over the Poles and Amazonis desert. The North Cap slowed its shrinking in Martian July and appeared to remain the same physical size, possibly due to renewed frost deposition. Early-evening observation revealed a blue Syrtis contrasting with a brilliant white Hellas region, which appeared brighter than the North Cap. No atmospheric blue-clearing or "green-haze" were detected during this period.

The Mars disk diameter decreased from 8″ in June to 6″ in July. Observations during June and July noted a general decrease in cloud and haze, and by the *Mariner IV* encounter date of July 14 the atmosphere was extremely clear with no evening limb or morning terminator haze present, no definite polar haze hoods, and only one local, small, evening equatorial cloud. No green haze opacity was detected on the atmospheric disk of Mars, because green-light photographs showed surface detail as clearly as did red-light photographs. A moderate atmospheric blue-clearing was noted visually at two different observatories and recorded photographically at Flagstaff on July 12, and continued weakly until July 19. The South Polar Cap had not been observed to date, although deposition was undoubtedly going on during this Martian midwinter season. This means that the cap edge had not yet reached a mean latitude of −65°, except on the Hellas plateau, which extends past −60° latitude. No definite south polar hood was observed, only the pseudo-whitening caused by the omnipresent white Hellas region. The North Cap remnant was observed occasionally covered by a weak haze, and remained approximately the same physical size. The southern maria were medium to dark contrasts of dark purple and brown color. The Syrtis Major was changing color from a blue-green to a green-blue hue. The Trivium Charontis showed only a moderate-contrast dark brown coloration. The contrast of the northern maria, oases, and canal-like features was decreasing.

A few observational checks were made of the North Polar Cap in August and September 1965 to learn if the cap remnant had completely melted and disappeared. The North Cap remnant retained a normal seasonal diameter of about six areocentric degrees.

# VII. MARTIAN POLAR REGIONS

The one attribute that makes the planet Mars unique among all the planets of the solar system and most Earth-like is that it displays white Polar Caps. The Polar Caps are affected by the seasonal position of the 24.8° inclined axis of Mars, which causes the caps to fluctuate in an annual seasonal cycle. Indeed, the great Martian mystery of the seasonal surface phenomena and the atmospheric conditions appears to be directly associated with the spring–summer melting phase of one Polar Cap and the autumn–winter formation phase of the opposite Cap; consequently, in the study of the polar regions lie clues to Martian phenomena.

The dazzling Polar Caps are generally the first features to be observed on the telescopic Martian disk. The Mars Caps exhibit greater seasonal latitude limits than do the Earth Caps. The Martian South Polar Cap becomes the larger during the long cold aphelion autumn–winter, has the faster melting rate, and becomes smaller during the shorter, hot spring–summer at perihelion. Contrariwise, the North Polar Cap is smaller because it is formed during the short perihelion winter, has a slow melting rate during the long cool spring–summer, and never has been observed to completely disappear. The terrestrial polar caps are each about 90° in width at the winter maximum. The Martian South Polar Cap can have a winter maximum as great as 100° across and summer minima of 5° to 0°, while the North Cap has limits between 53° to 80° diameter winter maxima and a 6° summer minimum.

Numerous reports on the Martian antarctic region investigations exist in the scientific literature, while little has been recorded about the long-term behavior of the arctic region, which is probably due to the observational handicaps encountered during the unfavorable aphelic oppositions. The Martian Polar Cap limits vary greatly from opposition to opposition and are defined differently by each individual investigator. More observations over a long time span of the Martian arctic region are necessary for a better understanding of the seasonal cycle and local weather of the northern hemisphere.

Historical literature has stated that the white substance observed covering the polar regions of Mars is some form of crystallized water formed under low-temperature conditions, such as hoarfrost, snow, ice, or a combination thereof. During the 1909 opposition, G. Tikhoff (Refs. 7 and 8), of the Poulkovo Observatory, made photometric and colorimetric studies on green, orange, and red plates; he found that the South Cap was brighter in green light than in red light. Similar tests on terrestrial sand versus ice showed that ice was darker than sand in red light, of equal intensity in orange light, brighter in green light, and still brighter in violet light; indicating that the Polar Caps of Mars could possibly consist of crystallized water. Photometric measurements of photographs taken during the 1939 apparition in selected light from red to violet by W. W. Scharonow of Tashkent Observatory further confirmed Tikhoff's results (Ref. 8). Working in the infrared on the North Polar Cap, G. P. Kuiper suggested that the Polar Caps are not composed of $CO_2$ but are probably a low-temperature $H_2O$ snowlike deposit, because terrestrial snow and hoarfrost appears nearly black beyond 20,000A, whereas dry ice remains white up to 25,000A (Refs. 8, 9). Polarimetric observations made by A. Dollfus indicated a low-temperature-formed fine granular surface structure. Recent spectroscopic observations of the Martian atmosphere by L. Kaplan, H. Spinrad, and G. Münch during the 1962 apparition (Ref. 10), and again by R. Schorn et al. in 1964–1965 (Ref. 11) have definitely detected water vapor. Very recently, work by Leovy and by Leighton and Murray has again suggested that the Caps may be $CO_2$ or $CO_2$ and $H_2O$ in combination, even though water is definitely present on Mars (Ref. 12).

In view of the above evidence and the repetitive nature of the observed seasonal data, a hypothetical model of the Martian Polar Caps can be constructed: The Polar Caps are chiefly formed under the great polar hood during the long winter night at low temperatures of possibly fine $H_2O$ and $CO_2$ crystals from surface contact condensation over a completely frozen substratum, which could conceivably consist of a water-soaked soil held in a permafrost condition in the higher latitudes. From the Pole at 90° latitude, down to about 85° or 80° latitude, a relatively thick inert central core probably exists, as is evidenced by the shape of the melt regression curves. Beyond the polar core the Cap thickness could be variable because of drifts and low ground and crevasses becoming filled with drifting crystals. The Cap would probably become quite variable in thickness at lower latitudes, with variable diurnal surface coverage of frost over the uneven periphery. The winter Cap with its ill-defined periphery of supercooled mists remains in this state until the approach of the equinox and the return of the day–night cycle. In early spring the surface frost apparently sublimates during the day without recongelation during the nightly deposition, which would tend to produce a fine granular surface during this season. As the subsolar point moves poleward with the march of the season, the thin peripheral frost and mists are burnt off and retreat toward the Pole. During the latter part of the spring season the Cap reaches its greatest rate-of-change (the change of physical state from a solid to a gas per unit time). It is at this time that the dark peripheral band develops and reaches its greatest contrast, width, and coloration.

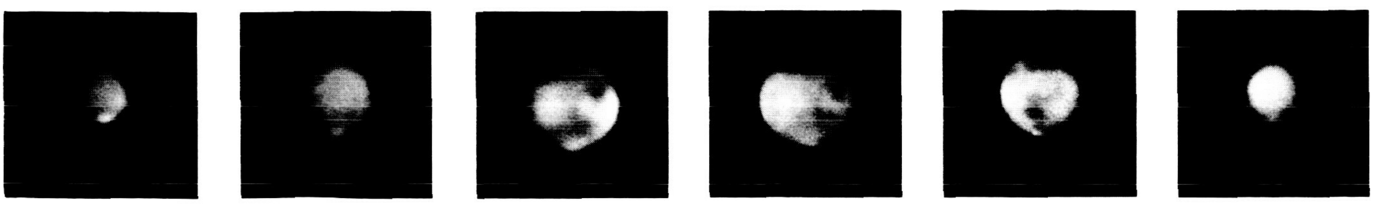
Polarimetric and colorimetric observations have indicated that the dark peripheral band has a smooth surface and may represent the only free water that exists on the surface of the planet. The rapid daily melting rate of the polar cap periphery and of the subsurface permafrost contiguous thereto may produce the 6 mb partial pressure in the cold atmosphere at the Cap edge, which is necessary for water to exist temporarily in that latitude as slush on a tundralike surface, which could be held in the top layer of the tundra by capillary action and a permafrost bed beneath. The water would freeze during the night and be held on the tundra surface until it melts again the next day, when some of it would be lost due to evaporation. This could explain the extremely bright arcs and smaller dazzling point areas observed at times on the edge of the Cap. Indeed, the observed dazzling points may be ice-covered mountainous crags or areas of frost-heave pingos. If free water does exist during this Martian season, it would surely only be a temporary event which follows the poleward retreat of the Cap, while sublimation would remain the chief method of Cap regression. If a tundralike surface really does exist on Mars, it could also imply the existence of terrestrial-type surface formations, such as the giant frost-heave pingos or the polygonal system of dikes and loose stone rings that are formed from frost action, freezing, and thawing; these formations could trap small pools of surface water during the time of the greatest rate-of-change of the Cap.

During Martian summer the rate-of-change slows as the Cap area decreases and as the more solid and thick core is reached. The dark peripheral band fades and narrows at this time. By late summer little change in the physical size of the Cap remnant can be detected. The North Polar Cap remnant is retained because of the short, cool northern summer season, whereas, the long, hot southern summer season usually causes the South Cap to disappear.

### A. Martian Polar Exploration, 1964–1965

Observation of the North Cap began two Martian days before the Martian vernal equinox and ended eight days after the Martian autumnal equinox. When first observed on September 11, 1964 (19 March MD), the North Cap was seen to be large and sharp with a weak morning limb haze on the following side of the disk. The north polar hood had apparently already dissipated in the returning sunlight of early spring and a darkening peripheral band indicated that the spring melt had just started. The North Cap extended down to about areographic latitude $+56°$; giving the Cap a breadth of $68°$, which is only $2°$ smaller than the normal average maximum diameter of $70°$ obtained by Lowell (Ref. 1), and $15°$ greater than the maximum of $53°$ set by Slipher (Ref. 2). A slow, normal melting rate of the Cap commenced about the first part of Martian April, and the greatest rate-of-change occurred during the last part of May and the first part of June. The seasonal aspect of the North Polar Cap for the 1964–1965 apparition is shown in Fig. 11.

An anomaly appeared in the physical size of the North Cap in early summer when it was observed clearly, both photographically and visually, through a morning



| | | | | | |
|---|---|---|---|---|---|
| Dec. 10, 1964 | Jan. 28, 1965 | Feb. 19, 1965 | Mar. 30, 1965 | Apr. 16, 1965 | May 17, 1965 |
| CM 251° | CM 123° | CM 249° | CM 249° | CM 44° | CM 139° |
| MD 1 May | MD 23 May | MD 2 June | MD 20 June | MD 28 June | MD 13 July |

**Fig. 11. Seasonal aspect of the North Polar Cap**

haze that turned into a weak polar hood eight days later. This arctic hood lasted for about ten days. During this period the rate-of-change ceased and the Cap remained the same size for eight days, and then grew a degree or so larger during the following sixteen days before it resumed a slow regression in the heat of Martian July. In late summer the rate-of-change once again ceased and the North Cap remnant became static at an areographic latitude of +87°, which defines a normal width of 6°; the same minimum width was determined by both Lowell and Slipher. A last observational check on the North Cap was made on the evening of October 12, 1965 (1 October MD), and it appeared very white, sharply defined, and again about 6° wide, apparently in a static state.

### B. North Polar Cap Retrogression

The melting regression of the North Polar Cap during the Martian spring and summer seasons was well recorded visually and photographically. North Polar Cap diameter measurements were made on 55 different photographic observations in red-orange light during 43 selected nights from October 3, 1964 (30 March MD) through July 14, 1965 (11 August MD). Likewise, green-light measurements were made on 31 different photographic observations during 30 selected nights from December 6, 1964 (29 April MD) through July 13, 1965 (11 August MD). An average of all measurements obtained from the best images of each selected night was made in an effort to reduce errors due to measurement, seeing conditions, film turbidity, and other image adjacency effects. The North Cap remnant was followed visually throughout August 1965, and was still clearly seen the last night of the Mars patrol on October 12, extending down to about +87° latitude.

The ratio between the measured North Polar Cap diameter and the planetary disk radius, irrelevant to the apparent disk diameter, produced the retrogression data and curves shown in Tables 1 and 2 and Fig. 12. The latitude $\phi$ of the polar cap periphery was found from

**Table 1. North Polar Cap red-light retrogression measurements**

| Observation number | UT date | AC/2r | Latitude $\phi$ | MD | Observation number | UT date | AC/2r | Latitude $\phi$ | MD |
|---|---|---|---|---|---|---|---|---|---|
| 3232 | Oct. 3, 1964 | 0.56 | +56.°0 | 30 Mar. | AG21, AG23 | Mar. 15 | 0.17 | 80.2 | 13 June |
| 3324 | Oct. 16 | 0.52 | 58.6 | 5 Apr. | AG44 | Mar. 20 | 0.18 | 79.6 | 16 June |
| 3477 | Nov. 21 | 0.52 | 58.6 | 22 Apr. | 4107 | Mar. 21 | 0.17 | 80.2 | 16 June |
| 3547 | Nov. 30 | 0.52 | 58.6 | 26 Apr. | AG49, AG50 | Mar. 23 | 0.16 | 80.7 | 17 June |
| 3573, 3574 | Dec. 6 | 0.51 | 59.3 | 29 Apr. | AG63, AG64 | Mar. 28 | 0.17 | 80.2 | 19 June |
| 3602 | Dec. 10 | 0.49 | 60.6 | 1 May | AG74 | Mar. 29 | 0.21 | 77.9 | 20 June |
| 3622 | Dec. 14 | 0.45 | 63.2 | 3 May | AG80, AG81, AG87 | Mar. 30 | 0.21 | 77.9 | 20 June |
| 3657 | Dec. 17 | 0.48 | 61.3 | 4 May | AG88 | Mar. 31 | 0.19 | 79.0 | 21 June |
| 3672 | Dec. 22 | 0.47 | 61.9 | 6 May | AG106 | Apr. 1 | 0.20 | 78.5 | 24 June |
| 3675, 3676 | Dec. 29 | 0.46 | 62.6 | 10 May | AG109, AG114 | Apr. 16 | 0.18 | 79.6 | 28 June |
| 3683, 3684, 3687 | Dec. 30 | 0.42 | 65.0 | 10 May | AG127, AG133 | Apr. 20 | 0.17 | 80.2 | 30 June |
| 3693, 3694 | Jan. 1, 1965 | 0.42 | 65.0 | 11 May | AG159 | Mar. 29 | 0.19 | 79.0 | 4 July |
| 3718 | Jan. 2 | 0.43 | 64.5 | 11 May | AG179 | May 6 | 0.18 | 79.6 | 8 July |
| 3749 | Jan. 11 | 0.43 | 64.5 | 15 May | AG185 | May 7 | 0.17 | 80.2 | 8 July |
| 3760 | Jan. 12 | 0.42 | 65.0 | 16 May | 4166 | May 10 | 0.18 | 79.6 | 10 July |
| 3799 | Jan. 23 | 0.40 | 66.4 | 21 May | McDonald 82-inch | May 19 | 0.17 | 80.2 | 14 July |
| 3814 | Jan. 28 | 0.36 | 68.9 | 23 May | 4186 | May 28 | 0.17 | 80.2 | 18 July |
| 3832 | Jan. 29 | 0.33 | 70.7 | 24 May | 4202 | June 5 | 0.16 | 80.7 | 22 July |
| 3871 | Feb. 2 | 0.32 | 71.3 | 26 May | 4210 | June 10 | 0.15 | 81.3 | 25 July |
| 3964 | Feb. 19 | 0.26 | 74.9 | 2 June | AG245 | July 2 | 0.15 | 81.3 | 5 Aug. |
| 4024 | Feb. 27 | 0.21 | 77.9 | 6 June | 4223 | July 8 | 0.12 | 83.1 | 8 Aug. |
| | | | | | McDonald 82-inch | July 14 | 0.10 | 84.3 | 11 Aug. |

**Table 2. North Polar Cap green-light retrogression measurements**

| Observation number | UT date | AC/2r | Latitude $\phi$ | MD |
|---|---|---|---|---|
| 3576 | Dec. 6, 1964 | 0.52 | $+58.^{\circ}6$ | 29 Apr. |
| 3601 | Dec. 10 | 0.53 | 57.9 | 1 May |
| 3640 | Dec. 15 | 0.53 | 57.9 | 3 May |
| 3656 | Dec. 17 | 0.51 | 59.3 | 4 May |
| 3677 | Dec. 29 | 0.49 | 60.6 | 10 May |
| 3695 | Jan. 1, 1965 | 0.43 | 64.5 | 11 May |
| 3736 | Jan. 10 | 0.42 | 65.1 | 15 May |
| 3837 | Jan. 29 | 0.31 | 71.9 | 24 May |
| 3842 | Jan. 30 | 0.30 | 72.5 | 24 May |
| 3877 | Feb. 2 | 0.28 | 73.7 | 26 May |
| 3901 | Feb. 12 | 0.28 | 73.7 | 30 May |
| 3908 | Feb. 13 | 0.29 | 73.1 | 31 May |
| 3918 | Feb. 16 | 0.27 | 74.3 | 1 June |
| 3960 | Feb. 19 | 0.27 | 74.3 | 2 June |
| 4025 | Feb. 27 | 0.22 | 77.2 | 6 June |
| 4059 | Mar. 9 | 0.22 | 77.2 | 11 June |
| AG55 | Mar. 23 | 0.23 | 76.7 | 17 June |
| 4125, AG83 | Mar. 30 | 0.26 | 74.9 | 20 June |
| AG88 | Mar. 31 | 0.21 | 77.8 | 21 June |
| AG109 | Apr. 16 | 0.20 | 78.4 | 28 June |
| AG171 | Apr. 30 | 0.22 | 77.2 | 5 July |
| AG172 | May 1 | 0.22 | 77.2 | 5 July |
| 4163 | May 10 | 0.23 | 76.7 | 10 July |
| 4173 | May 16 | 0.21 | 77.8 | 13 July |
| 4189 | May 28 | 0.19 | 79.0 | 18 July |
| AG193 | June 15 | 0.17 | 80.2 | 27 July |
| AG204 | June 18 | 0.15 | 81.3 | 29 July |
| AG220 | June 23 | 0.13 | 82.5 | 31 July |
| AG249 | July 2 | 0.13 | 82.5 | 5 Aug. |
| AG265 | July 13 | 0.11 | 83.7 | 11 Aug. |

$\cos \phi = AC/2r$, where $AC$ is the polar cap diameter and $r$ is the radius of the Martian disk in Fig. 13. All measurements have been corrected for the phase effect of the "defect of illumination" on the planetary disk. The eccentricity of the North Cap relative to the axis of rotation is only 1 degree and therefore need not be considered. Laboratory tests, photographic observations, and visual observations all clearly indicate that the Polar Caps of Mars appear brighter in green light than in orange or red light. This fact is reflected in the yellow-green light dashed retrogression curve relative to the orange and red light solid curve (Fig. 12). The yellow-green retrogression dashed curve produced a larger size Cap than did the orange and red solid curve, which is caused by film turbidity. The red-orange measurements more closely approximate the visual measurements that have been filter-corrected for irradiation.

The North Polar Cap retrogression curves defined a steady slope of about 1 degree of areocentric latitude per 23-day period during Martian April, which increased to about 1 degree per 3-day period during Martian May; and shows a halt in the melting rate on or about 13 June MD that lasted until 10 July MD. The decrease in the melting rate was associated with an early morning haze that was detected lying over the arctic region on March 10 terrestrial date, which turned into an arctic hood by March 18 TD. Photographic and visual observation presented evidence that Polar Cap deposition had occurred at times during the period March 18 TD through the first week of April. Numerous haze and white frost patches were noted contiguous to the irregular periphery of the North Cap during this period. It is interesting to compare these arctic phenomena with the Elysium region cloud and frost storm activity during the same period. During Martian July the regression rate remained slow at 1 degree per 26-day period. The first two weeks of Martian August showed an increase to 1 degree per 5-day period, and by the end of Martian August the curve defined a melting rate of only about 1 degree per 30 days. Observation indicated that the melting had ceased some time in late Martian September, retaining about a 6° diameter Cap remnant.

## C. North Cap Peripheral Melt-Band

The north cap peripheral band behaved anomalously during nearly the entire apparition. The cap periphery began the apparition with a normal spring medium-contrast appearance, becoming broader and darker in Martian April as the rate-of-change just began to increase, and then in May it became thinner and weaker, remaining as an inactive sharply defined, thin, weak, medium gray-brown arc contiguous to the Polar Cap. Only during the latter part of Martian June did the north cap peripheral band show any activity, when it became a moderate, broad, dark blue-gray and dark brown band. The peripheral band faded back to an inconspicuous feature by 4 July MD, and it remained thus till the end of the apparition.

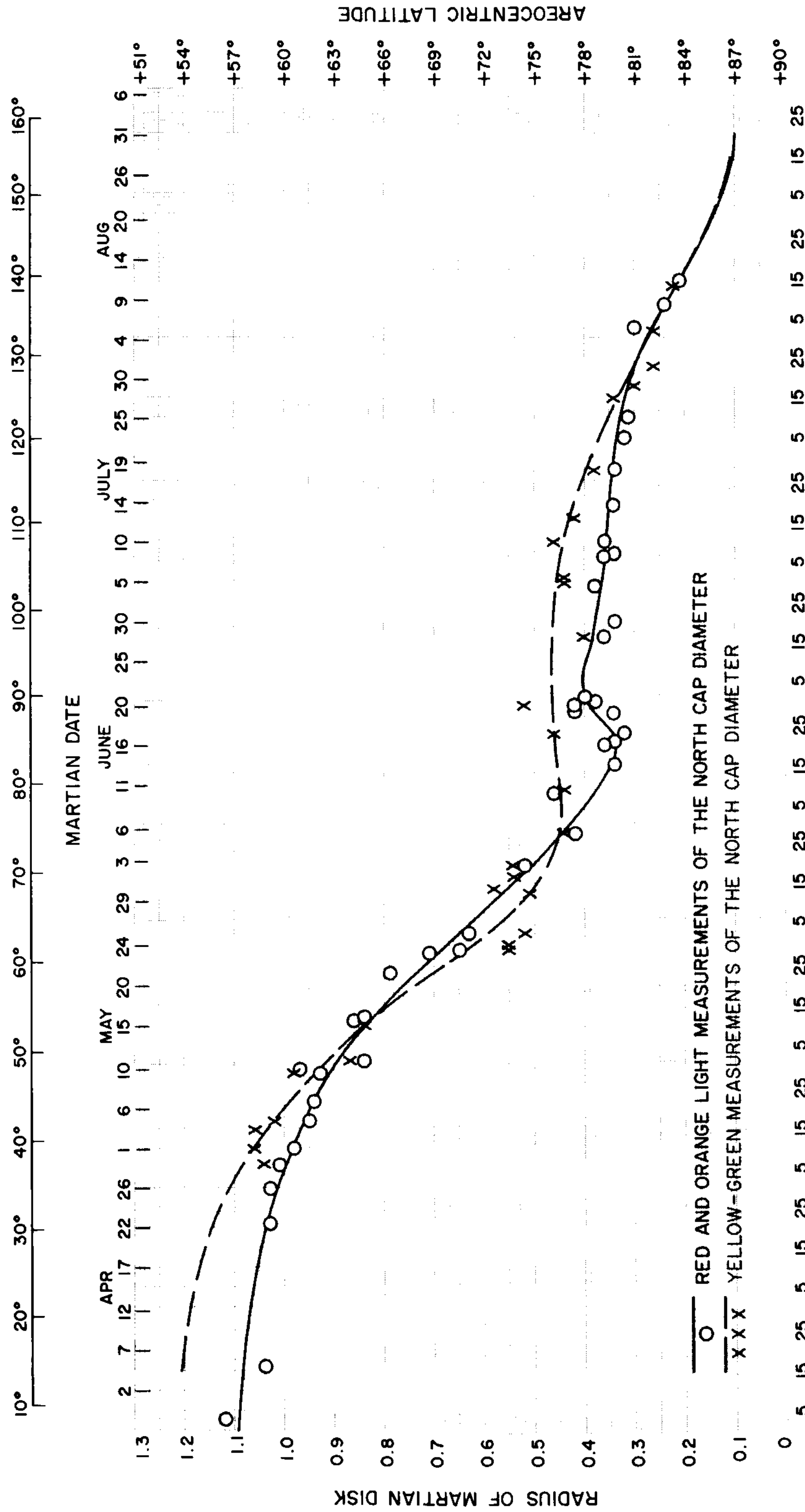



Fig. 12. North Polar Cap retrogression curves

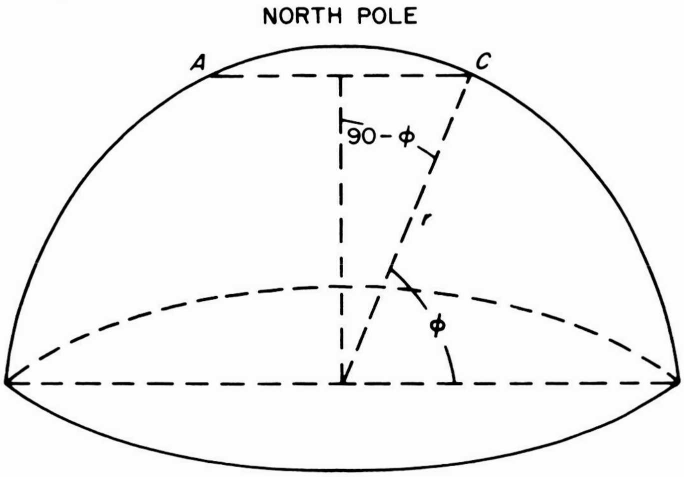



Fig. 13. Geometry of Polar Cap measurements

## D. Abnormality and Color of the North Cap

The North Cap appeared a dull, gray-white at times throughout the apparition because of local haze and cloud coverage. About the time of vernal equinox the North Cap was possibly an off-white or slightly yellowish hue. The Cap was definitely a yellow-white from the 5th to the 7th of Martian June and appeared a definite ocher desert orange color on the 8th and 9th of Martian June. During the return of the north polar hood in Martian mid-June the Cap took on a dull, gray-blue appearance. It was during this arctic haze activity that the North Cap edge became irregular in outline on 20 June MD, and a large, detached newly deposited frost area was observed on 21 June MD. Photographs and drawings (Fig. 14) showed the North Cap to be bright white and irregular in outline from 28 June MD through 30 June MD, and again the first week of Martian July. Early in Martian July an arc on the edge of the North Cap became extremely bright. During Martian August the Cap remained a symmetrical compass.

## E. The South Cap

The South Cap was vaguely observed only once during the entire apparition. The South Cap was seen through a weak antarctic hood during the last observation of the apparition with a Martian seasonal date of 1 October and a planetary axial tilt of only +9.°6, which indicates that the South Polar Cap had a breadth greater than 20° at this season. Evidence of antarctic frost deposition was

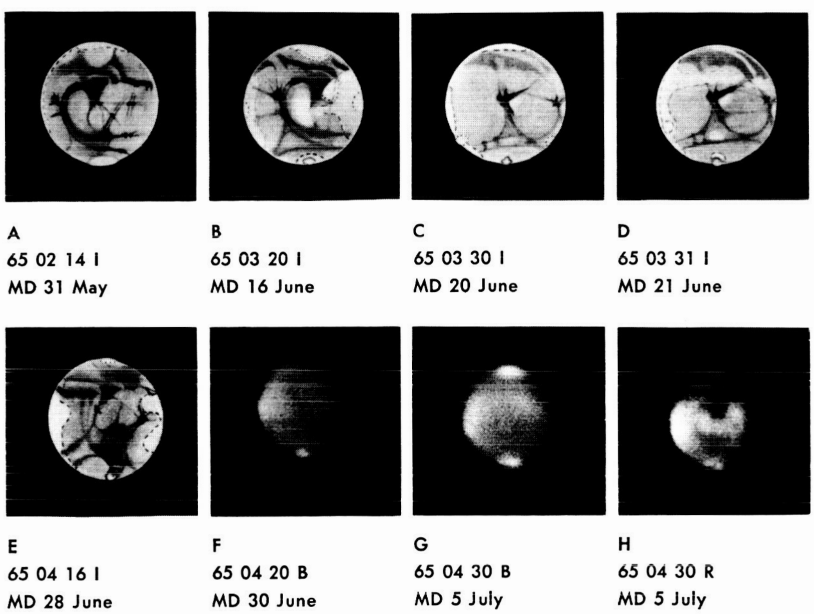



Fig. 14. Photographs and drawings of various aspects and abnormalities of the North Cap: drawing A depicts a normal regressing, haze-free, and bright white Cap; a haze is seen forming over the small late-spring North Cap in drawing B; an irregular Cap periphery has formed in drawing C; a new detached frost or ice-fog deposition is evident in drawing D surrounding part of the temporarily enlarged North Cap; drawing E records a shrinking summer white Cap with a melt-rift located at about 45° longitude and peripheral projections at coordinates 20°, +70° and 60°, +78°; photograph F shows an irregular Cap periphery with a melt-rift; photograph G records an evening blue haze and frost deposit on the evening side of the Cap; and the red-light image H, obtained during the same observing period, records a fresh white surface deposit beneath the haze

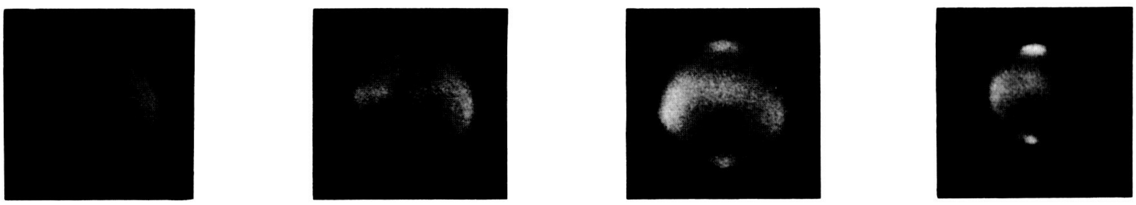
noted on the nightly observation of October 21, 1964 (7–8 April MD), which lasted until 14 April MD. During the above period, through a weak haze, the southern light areas were also observed to be covered with frost. The lower part of the Hellas plateau from −30° to −50° latitude was particularly bright during this same period.

### F. The South Polar Hood

The antarctic region was covered by polar haze hoods for several long periods during this apparition (Fig. 15). Around the time of vernal equinox the south polar hood was seen to extend down to about −65° areographic latitude, defining a 50° width. Antarctic haze was light and sporadic in Martian April and May during the early melting phase of the North Cap. Extensive and dense south polar hoods started to develop about Martian June, and became a more or less southern autumn–winter entity by Martian August. Table 3 below presents some south polar hood photographic measurements during periods of antarctic haze activity, and shows their respective extent in aerocentric degrees. The measurements were corrected for the phase effect of the "defect of illumination."

**Table 3. South polar hood measurements**

| Observation number | UT date | AC/2r | Latitude $\phi$ | Areo-centric | MD |
|---|---|---|---|---|---|
| 3936 | Feb. 17, 1965 | 0.44 | −63°.9 | 52° | 1 June |
| 4115 | Mar. 21 | 0.44 | −63.9 | 52 | 16 June |
| AG150 | Apr. 27 | 0.43 | −64.5 | 51 | 4 July |
| AG162 | Apr. 29 | 0.41 | −65.8 | 48 | 4–5 July |



A
65 02 17 V
MD 1 June
Tenuous south haze

B
65 02 27 B
MD 6 June
No polar hood

C
65 03 21 UV
MD 16 June
Large south hood

D
65 04 29 B
MD 4 July
Dense south hood

**Fig. 15. South polar hood**

## VIII. ATMOSPHERIC AND METEOROLOGICAL PHENOMENA

The Martian atmospheric visible clouds are classified according to the color of light in which they are best observed. Blue-white clouds record brightly in blue and violet light at their respective medium and high altitudes, and are perhaps $H_2O$ cirrus or solid $CO_2$ particles. Yellow clouds show prominently in red, orange, and yellow-green light and possibly consist of surface dust generated by cyclonic activity. The bright yellow clouds are infrequent in historical literature. Morning-limb blue hazes are frequently observed over the ocher deserts as well as over the dark gray maria. Accompanying early-morning frosts are also frequently recorded, but recur at given surface positions.

A high-quality synoptic observational record of the atmospheric phenomena was obtained during the 1964–1965 aphelic apparition. Several bright and dense polar hoods were recorded. The normal blue-white cloud activity increased during the late spring season, and many well defined terminator cloud projections and localized recurrent cloud activity were photographed. No confirmed yellow clouds were discovered during this apparition; only the aftermath evidence of a possible dust storm was found late in the Martian spring.

### A. Atmospheric Cloud and Haze Statistical Survey

Table 4 is a rigorous survey of Martian atmospheric phenomena from all available violet- and blue-light data for the entire 1964–1965 apparition, which covered the spring–summer in the northern hemisphere and fall–winter in the south. The survey is limited because 100% Martian longitudinal coverage was not possible, but certainly major trends are indicated; 412 separate observations were examined for polar hoods or haze (PH), morning haze (MH), evening haze (EH), morning clouds (MC), evening clouds (EC), and cloud bands (CB). The terrestrial date (TD) is given for each period in the first column versus the Martian date (MD) in the final column.

The percentages of observing days exhibiting the various atmospheric phenomena during the 1964–1965 apparition are as follows:

| | |
|---|---|
| Arctic hood or haze | 23.0% |
| Antarctic hood or haze | 45.0% |
| Morning haze | 45.2% |
| Evening haze | 22.6% |
| Morning cloud | 22.6% |
| Afternoon cloud | 64.5% |
| Cloud band | 15.5% |
| Recurrent cloud activity | 20.7% |
| Terminator projection | 5.8% |

The survey showed that haze over the south polar region was more prevalent than over the north polar region, limb haze occurred twice as often in the morning as in the evening, and afternoon cloud activity was three times higher than in the morning.

### B. Terminator Cloud Projections

An evening-terminator high-altitude cloud projection was immediately picked up on the first observation of the apparition on the morning of September 11, 1964 TD, at 320° to 345° longitude and about −20° to −30° latitude, and it was followed down the terminator to the Equator during the next succeeding 18 days. This evening cloud was not seen on the dark phase of the planetary disk on October 1, although hazy evidence of it was noted on the evening twilight portion of the disk approximately centered on the Equator over the Amazonis desert.

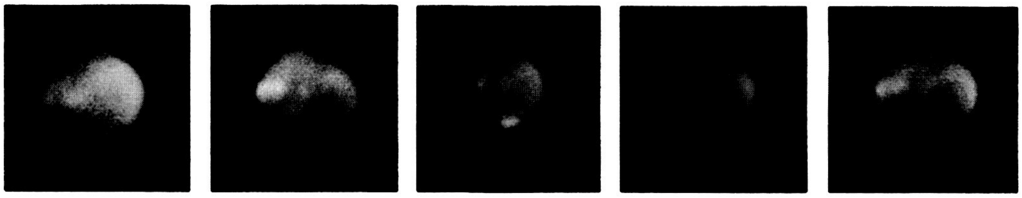
Another well developed violet and blue evening terminator cloud was observed centered on the Equator on December 10, 1964 TD, and it lasted until December 22 TD. Terminator cloud activity increased during the late Martian spring season (Jan. 23–Feb. 19 TD) until the full disk phase changed them into afternoon-limb clouds.

### C. Recurrent Clouds

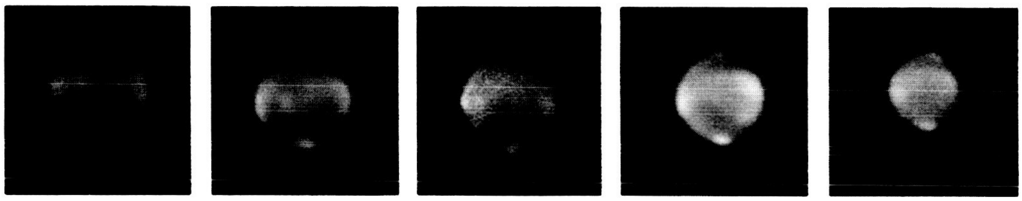
Recurrent clouds have been observed to form over the same areas of the Martian surface for the past 62 years. Individual clouds are photographed in violet and blue light, and sometimes recorded in yellow-green light (Fig. 16). The recurrent cloud activity is observed to be greatest during the late spring season at maximum rate-of-change of the Polar Cap. The most interesting behavior of these clouds is that most often they are seen forming in the light of afternoon; although on a few occasions certain clouds have been seen again on the sunrise limb of the planet, apparently lasting throughout the cold Martian night. Usually, the clouds appear small and tenuous around two o'clock in the Martian afternoon, and gradually develop during late afternoon, when at sunset they are most prominent, large, and bright. They are not usually observed on the following morning limb, but are once again seen to reform during the Martian afternoon.

Certain areas on the Martian surface are conducive to cloud generation. The Candor–Tharsis desert region just below the Martian Eye of the Thaumasia is one such cloud-active area. Since 1907 clouds have been repeatedly observed in this region, wrapped around the northern perimeter of the Coprates Triangle complex, from the Aurorae Sinus to the Phoenicis Lacus, forming the now famous "W cloud" group. The Elysium and Hellas plateaux also show a marked tendency for well defined afternoon cloud formation. Other such areas lie in the great wastes of the Arcadia–Amazonis desert at the following 1965 measured center-of-area coordinates: A) 109° long., +14° lat., near Ascaeus Lacus; B) 136°, +19°, Nix Olympica; C) 117°, +43°, not near any registered feature in the Arcadia desert. The above A, B, and C cloud measurements agree well with the Lowell Observatory photographic three-cloud measurements obtained by K. DeGroff (Ref. 13). The existence and frequency of defined cloud formations over given surface positions suggests that they may owe their generation to a certain type of surface feature that produces some sort of meteorological mechanism.

Cloud measurements were obtained by Central Meridian transits and by projecting the blue Mars image onto



| A | B | C | D | E |
|---|---|---|---|---|
| 50 02 16 B | 50 03 18 B | 65 01 30 B | 65 02 18 B | 65 02 27 B |
| CM 148° | CM 173° | CM 134° | CM 241° | CM 135° |
| MD 10 June | MD 24 June | MD 24 May | MD 2 June | MD 6 June |
| Lowell Obs. | Lowell Obs. | TMO. | TMO. | TMO. |



| F | G | H | I | J |
|---|---|---|---|---|
| 65 03 04 V | 65 03 28 B | 65 03 31 CB | 65 04 16 V | 65 05 01 V |
| CM 119° | CM 243° | CM 175° | CM 56° | CM 291° |
| MD 8 June | MD 19 June | MD 21 June | MD 28 June | MD 5 July |
| TMO. | TMO. | TMO. | TMO. | TMO. |

**Fig. 16. Violet- and blue-light photographs of recurrent clouds relative to defined areographic areas during the Martian spring and summer seasons: afternoon recurrent cloud activity over the Arcadia–Amazonis desert region is shown in photographic images A, B, C, E, F, and H; recurrent cloud formation over the Elysium area is shown in images D and G; afternoon clouds are often recorded over the Edom–Eden region, as shown in image I**

a spherical grid with a tilt equal to the planetary tilt. Clouds within ±30° longitude from the CM have center-of-area measuring errors of ±2°, clouds near the evening limb can have systematic errors as great as +5° because of the difficulty of locating the true center-of-area of the cloud mass and the distortion due to limb effect. Some of the clouds' measured centers-of-area, approximate dimensions and physical size, and dates when observed are as follows:

The Amazonis–Arcadia region (Fig. 17) meteorological phenomena were observed during Martian 20 May through 24 May in blue light.

*Cloud A* was recorded on January 23, 26, 28, 29, and 30, 1965 TD.

Ca. coordinates 102°, +4° (blue light).

Cloud coverage 90° to 114° long., −1° to +25° lat.

Physical dimensions 24° × 26° or ≃ 2.10 × $10^6$ $km^2$.

*Cloud B* was recorded on January 21, 23, 28, and 30, 1965 TD.

Ca. coordinates 135°, +19° (blue light).

Cloud coverage 130° to 140° long., +9° to +30° lat.

Physical dimensions 10° × 21° or ≃ 0.69 × $10^6$ $km^2$.

CM 135°

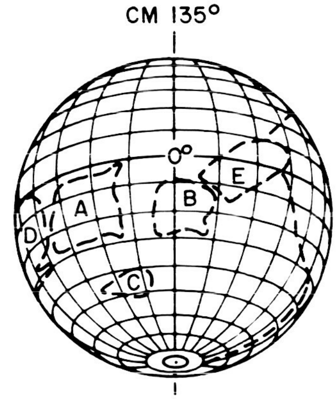



**Fig. 17. Positions of recurrent clouds over the Tempe–Arcadia–Amazonis region**

*Cloud C* was recorded on January 23, 28, and 30, 1965 TD.

Ca. coordinates 116°, +44° (blue light).

Cloud coverage 108° to 130° long., +33° to +57° lat.

Physical dimensions 22° × 24° or ≃ 1.29 × $10^6$ $km^2$.

An Elysium plateau (Fig. 18) afternoon blue cloud buildup was noted from Martian 26 May through 21 June.

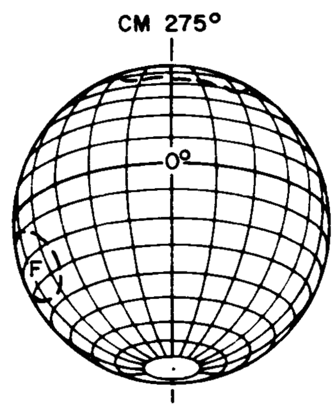



**Fig. 18. Position of a recurrent cloud over the Elysium area**

*Cloud F* was recorded on February 2, 15, 16, 17, 18, 19, 20, 26, and 27, and March 1, 27, 28, 29, 30, and 31, 1965 TD.

Ca. coordinates 220°, +25° (blue light).

Cloud coverage 204° to 240° long., +9° to +37° lat.

Physical dimensions for February 17 and 18 were 36° × 28° or ≃ 3.36 × $10^6$ $km^2$.

Atmospheric cloud phenomena was observed over the Amazonis–Arcadia–Tharsis deserts during Martian 5 through 9 June in violet, blue, and yellow-green light.

*Cloud A* was photographed on the nights of February 25, 26, and 27, and March 1, 4, and 6, 1965 TD.

Ca. coordinates 111°, + 14° (blue and green light).

Cloud coverage 100° to 123° long., +4° to +24° lat.

Physical dimensions 23° × 20° or ≃ 1.21 × $10^6$ $km^2$.

*Cloud B* was photographed on February 26 and 27, and March 1, 2, 4, and 6, 1965 TD.

Ca. coordinates 136°, +18° (blue and green light).

Cloud coverage 130° to 145° long., +09° to +29° lat.

Physical dimensions 15° × 20° or ≃ 0.97 × $10^6$ $km^2$.

*Cloud C* was photographed on February 25, 26, and 27, and March 1, 2, 4, and 6, 1965 TD.

Ca. coordinates 117°, +45° (blue and green light).

Cloud coverage 109° to 125° long., +39° to +51° lat.

Physical dimensions 16° × 12° or ≃ 0.43 × $10^6$ $km^2$.

*Cloud D* was recorded on the nights of February 26 and 27, and March 1, 4, and 6, 1965 TD.

Ca. coordinates 88°, +11° (blue and green light).

Cloud coverage 70° to 99° long., 0° to +25° lat.

Physical dimensions 29° × 25° or ≃ 2.57 × $10^6$ $km^2$.

*Cloud E* was photographed on February 26 and 27, and March 1 and 4, 1965 TD.

Ca. coordinates 161°, +01° (blue light).

Cloud coverage 147° to 166° long., −11° to +14° lat.

Physical dimensions 19° × 25° or ≃ 1.68 × $10^6$ $km^2$.

Violet-light averaged cloud measurements for the observing periods of March 4 and 6 TD follow for comparison with the blue and yellow-green data:

*Cloud A*

Ca. coordinates 113°, +14° (violet light).

Cloud coverage 99° to 118° long., +4° to +24° lat.

Physical dimensions 19° × 20° or ≃ 1.03 × $10^6$ $km^2$.

*Cloud B*

Ca. coordinates 136°, +19° (violet light).

Cloud coverage 124° to 144° long., +09° to +29° lat.

Physical dimensions 20° × 20° or ≃ 1.02 × $10^6$ $km^2$.

*Cloud C*

Ca. coordinates 118°, +40° (violet light).

Cloud coverage 110° to 121° long., +30° to +54° lat.

Physical dimensions 11° × 24° or ≃ 0.76 × $10^6$ $km^2$.

*Cloud D*

Ca. coordinates 88°, +09° (violet light).

Cloud coverage 69° to 95° long., −09° to + 20° lat.

Physical dimensions 26° × 29° or ≃ 2.58 × $10^6$ km².

Recurrent cloud formations were seen over the Arcadia–Amazonis desert and the Elysium plateau during 20–21 June MD. The clouds were best recorded in blue and violet light; however, they were also registered more diffusely in yellow-green light.

*Cloud B* was photographed on March 31 and April 1, 1965 TD.

Ca. position 136°, +16°.

Cloud coverage 122° to 148° long., 0° to +26° lat.

Physical dimensions 26° × 26° or ≃ 1.79 × $10^6$ km².

*Cloud E* was recorded on March 30 and 31, and April 1, 1965 TD.

Ca. position 153°, +16°.

Cloud coverage 147° to 159° long., +10° to +26° lat.

Physical dimensions 12° × 16° or ≃ 0.51 × $10^6$ km².

*Cloud F* was recorded on March 30 and 31, and April 1, 1965 TD.

Ca. position 215°, +19°.

Cloud coverage 197° to 235° long., 0° to +35° lat.

Physical dimensions 38° × 35° or ≃ 4.31 × $10^6$ km².

*Cloud G* was photographed on March 31 and April 1, 1965 TD.

Ca. position 142°, +40°.

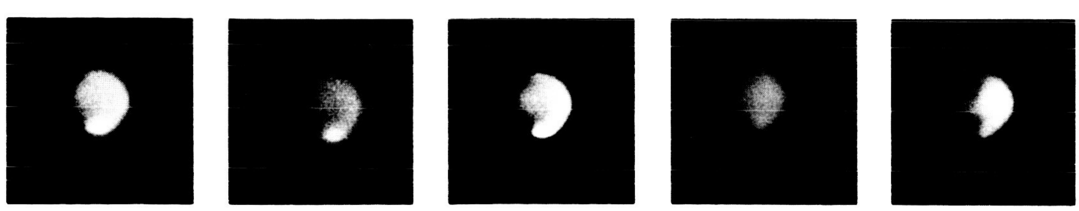
Cloud coverage 134° to 149° long., +30° to +58° lat.

Physical dimensions 15° × 28° or ≃ 1.21 × $10^6$ km².

### D. The Evolution of an Atmospheric Dark Streak

An unusually interesting discovery was the atmospheric phenomenon of fine-line dark streaks on a couple of the Table Mountain violet- and blue-light images during the 1962–1963 apparition. A similar occurrence of a dark streak was discovered in violet and blue light on the evenings of January 9 through 12, 1965 TD (Fig. 19); with the given planetary conditions: disk diameter 9″.2 of arc; terminator width 33°.7; axial tilt 22°.6; and a seasonal date of 15–16 May MD.

On January 9 TD (15 May MD) a long, fine, dark streak was photographed in blue light in the southern hemisphere extending from the evening terminator at coordinates 246° longitude, −30° latitude, and slanting across the opaque blue disk to the morning limb at coordinates 30° longitude, −10° latitude. This atmospheric feature was in a juxtaposition with the Mare Tyrrhenum on the surface. Its reality was confirmed by its appearance on many images of the same blue plate, on composite images, and on different sets of plates for four individual nights. The streak became wider and better defined on January 10 TD, and changed its position to approximately 250° longitude, −30° latitude on the terminator to 30° longitude, 0° latitude on the morning limb. The slanting streak was again evident on the January 11 blue plate as a broad and diffuse band centered on the −20° parallel. The dark atmospheric feature was last seen on January 12 in blue light as a vague,



| January 9 | January 10 | January 11 | January 12 | January 11 |
|---|---|---|---|---|
| Blue light | Blue light | Violet light | Blue light | Red light |
| CM 303° | CM 306° | CM 290° | CM 302° | CM 292° |

**Fig. 19. A dark streak in the southern atmosphere of Mars; the first four photographs are blue- or violet-light images; the last photograph is a red-light image for surface feature comparison**

| TD (UT) | PH | | MH | | EH | | MC | |
|---|---|---|---|---|---|---|---|---|
| | Occurrence | Latitude, ° | Occurrence | Latitude, ° | Occurrence | Latitude, ° | Occurrence | Latitude, ° |
| Sept. 11, 1964 | X | −90 | X | −10, +90 | | | | |
| 17 | X | −90 | X | −10, +90 | | | | |
| 19 | X | −90 | X | 0, +90 | | | | |
| 26 | X | −90 | | | | | | |
| 28 | | | | | | | | |
| 29 | | | X | 0, +60 | | | X | −5 |
| 30 | | | | | | | | |
| Oct. 1 | | | X | 0 | | | | |
| 3 | | | | | | | | |
| 4 | | | | | | | | |
| 5 | | | | | X | −10, +30 | | |
| 6 | | | X | −10, +45 | X | −30, +40 | | |
| 7 | X | −90 | X | 0, +50 | | | | |
| 9 | X | −90 | X | 0, +90 | X | −35, −90 | | |
| 11 | X | −90 | | | | | | |
| 12 | X | −90 | X | 0, +65 | X | 0, +30 | | |
| 13 | X | −90 | | | | | | |
| 16 | X | −90 | X | −5, +10 | | | | |
| 18 | X | −90 | X | −10, +90 | | | | |
| 20 | X X | −90, +90 | X | −10, +90 | | | | |
| 21 | X | −90 | X | 0, +90 | X | 0, −65 | | |
| 25 | X | −90 | X | 0, +65 | X | −90, +20 | X | +10 |
| Nov. 4 | X | −90 | | | | | | |
| 21 | X | −90 | X | 0 | | | | |
| 23 | X | −90 | X | 0 | | | | |
| 24 | X | −90 | X | 0 | | | | |
| Dec. 6 | X | −90 | X | 0, +40 | | | | |
| 7 | X | −90 | X | 0, +40 | | | | |
| 10 | X | −90 | X | −5, +35 | | | X | 0 |
| 14 | X | −90 | X | +20, +65 | | | | |
| 15 | X | −90 | X | +20, +65 | | | | |
| 17 | X | −90 | X | +20, +65 | | | | |
| 22 | | | | | | | | |
| 30 | | | X | −10, +40 | | | | |

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Table 4. Martian atmospheric phenomena, 1964—1965

| | EC | | | CB | | MD | Remarks |
|---|---|---|---|---|---|---|---|
| Longitude, ° | Occurrence | Latitude, ° | Longitude, ° | Occurrence | Latitude, ° | | |
| | X | −20, −30 | 320, 345 | | | 19 Mar. | Terminator projection. |
| | X | −5 or −10 | 320, 345 | | | 22 | Terminator projection. |
| | X | −5, +22 | 240, 285 | | | 23 | Terminator projection. |
| | X | −12, +20 | 180, 210 | | | 27 | |
| | X | −15, +10 | 150, 180 | | | 28 | |
| 280 | X | −15, +20 | 154, 210 | | | 28 | Terminator projection. |
| | X | −20, 0 | 123, 138 | | | 29 | |
| | X | 0 | 145 | | | 29 | Questionable evening cloud. |
| | X | 0 | 145 | | | 30 | Questionable evening cloud. |
| | X | −15, +25 | 115, 125 | | | 31 | |
| | X | −10, +25 | 70, 115 | | | 31 | Increasing terminator cloud; high-altitude evening haze. |
| | X | −10, +15 | 75, 105 | | | 31 | |
| | X | −10, +50 | 55, 110 | | | 1 Apr. | |
| | | | | | | 2 | |
| | | | | | | 3 | |
| | | | | | | 3 | |
| | | | | | | 4 | |
| | | | | | | 5 | A possible morning haze was noted. |
| | | | | | | 6 | |
| | | | | | | 7 | |
| | | | | | | 7–8 | |
| 28 | | | | | | 10 | |
| | | | | | | 14 | |
| | | | | | | 22 | |
| | | | | | | 23 | |
| | | | | | | 24 | |
| | | | | | | 29 | |
| | | | | | | 30 | |
| 310 | X | −20, +20 | 185, 200 | | | 1 May | |
| | X | +10 | 160 | | | 3 | |
| | X | −10, +45 | 140, 180 | | | 3 | |
| | X | −10, +45 | 140, 180 | | | 4 | |
| | X | 0, +20 | 40, 60 | | | 6 | |
| | | | | | | 10 | |

Table 4 (Cont'd)

| TD (UT) | PH |  | MH |  | EH |  | MC |  |  | O |
|---|---|---|---|---|---|---|---|---|---|---|
|  | Occurrence | Latitude, ° | Occurrence | Latitude, ° | Occurrence | Latitude, ° | Occurrence | Latitude, ° | Longitude, ° | O |
| Jan. 1, 1965 |  |  | X | −10, +40 |  |  |  |  |  |  |
| 2 |  |  | X | −10, +40 |  |  |  |  |  |  |
| 10 | X | −90 | X | 0, −90 | X | 0, −90 |  |  |  |  |
| 11 |  |  | X | 0, +30 |  |  | X | 0, +30 | 0 |  |
| 21 |  |  | X | −40, +40 |  |  |  |  |  |  |
| 23 |  |  | X | −40, +40 |  |  |  |  |  |  |
| 26 |  |  | X | +10, +65 |  |  | X | +10 | 206 |  |
| 28 |  |  | X | −40, +50 |  |  | X | +10 | 206 |  |
| 29 |  |  | X | −30, +40 |  |  |  |  |  |  |
| 30 |  |  | X | −10, +20 |  |  |  |  |  |  |
| 31 |  |  | X | −15, +40 |  |  |  |  |  |  |
| Feb. 2 |  |  | X | −40, +70 |  |  |  |  |  |  |
| 3 |  |  | X | −10, +40 |  |  |  |  |  |  |
| 12 | X | −90 | X | −20, +40 |  |  |  |  |  |  |
| 13 | X | −90 | X | −20, +40 |  |  |  |  |  |  |
| 14 | X | −90 |  |  |  |  |  |  |  |  |
| 15 | X | −90 |  |  | X | −10, +35 |  |  |  |  |
| 16 | X | −90 | X | −20, +40 |  |  |  |  |  |  |
| 17 | X | −90 |  |  |  |  |  |  |  |  |
| 18 | X | −90 |  |  |  |  |  |  |  |  |
| 19 | X | −90 |  |  |  |  | X | +10 | 310 |  |
| 20 | X | −90 |  |  |  |  | X | +10 | 310 |  |
| 21 | X | −90 |  |  |  |  | X | +10 | 315 |  |
| 25 | X | −90 |  |  |  |  |  |  |  |  |
| 26 | X | −90 | X | −8, +45 |  |  | X | +25 | 215 |  |
| 27 |  |  | X | −20, +35 |  |  | X | +25 | 215 |  |
| Mar. 1 |  |  | X | −25, +60 |  |  | X | +5 | 210 |  |
| 2 |  |  | X | −25, +20 |  |  | X | +25 | 200 |  |
| 4 | X X | −90, +70 | X | −12, +45 |  |  |  |  |  |  |
| 6 |  |  | X | −12, +40 |  |  |  |  |  |  |
| 8 |  |  | X | +22, +58 |  |  |  |  |  |  |
| 9 | X | −90 | X | −10, +45 |  |  | X | +20 | 160 |  |
| 10 | X X | −90, +90 | X | 0, +85 |  |  |  |  |  |  |
| 15 | X | +90 | X | −15, +50 |  |  |  |  |  |  |

| EC | | | CB | | MD | Remarks |
|---|---|---|---|---|---|---|
| urrence | Latitude, ° | Longitude, ° | Occurrence | Latitude, ° | | |
| | | | | | 11 May | |
| | | | | | 11 | |
| | | | X | +20 | 15 | Low-altitude cloud band. |
| | | | | | 15–16 | |
| X | +25 | 135 | | | 20 | |
| X | +20, +45 | 120, 140 | | | 21 | Recurrent clouds A, B, and C. |
| X | +10 | 108 | | | 22 | Terminator projection; recurrent cloud A. |
| X | +15 | 80 | X | −20 | 23 | Recurrent clouds A, B, and C.<br>Terminator projection. |
| X | +10 | 95 | X | −20 | 24 | Terminator projection; recurrent cloud A.<br>Cloud band breaking into cloud concentrations. |
| X | −45, +10 | 95, 116 | | | 24 | Recurrent clouds A, B, and C. |
| X | 0, −20 | 0, 65 | | | 25 | |
| X | 0, +35 | | X | 0 | 26 | Terminator projection.<br>Recurrent cloud F. |
| X | 0, +35 | | X | 0 | 26 | Equatorial cloud band. |
| X | 0, +30 | 240, 280 | X | 0 | 30 | Equatorial cloud band. |
| X | −10, +30 | 270, 290 | X | 0 | 31 | Equatorial cloud band. |
| X | +10, +35 | 200, 230 | X | 0 | 31 | |
| X | +25 | 220 | X | 0 | 1 June | Recurrent cloud F. |
| X | +25 | 219 | X | 0 | 1 | Recurrent cloud F. |
| X | +25 | 220 | | | 1 | Recurrent cloud F. |
| X | 0, +25 | 161, 225 | | | 2 | Recurrent clouds E and F. |
| X | 0, +20 | 160, 230 | | | 2 | Recurrent clouds B, E, and F. |
| X | 0, +25 | 130, 230 | | | 3 | Recurrent clouds B, E, and F. |
| X | 0, +20 | 175, 200 | X | 0 | 3 | |
| X | 0, +45 | 95, 112 | X | 0 | 5 | Recurrent clouds A and C. |
| X | +15, +46 | 111, 136 | | | 5–6 | Recurrent clouds B, C, D, E, and F. |
| X | +2, +46 | 95, 161 | | | 6 | Recurrent clouds A, B, C, D, E, and F. |
| X | 0, +50 | 70, 245 | | | 7 | Recurrent clouds A, B, C, D, E, and F. |
| X | +9, +50 | 109, 145 | X | 0 | 8 | Recurrent clouds B and C. |
| X | +9, +50 | 88, 166 | | | 8 | Recurrent clouds A, B, C, D, and E.<br>North polar cloud 104°, +70° ca. |
| X | +9, +50 | 88, 166 | | | 9 | Recurrent clouds A, B, C, D, and E. |
| X | +25 | 350 | | | 10 | |
| X | 0 | 350 | | | 11 | |
| X | +25 | 315 | | | 11 | |
| | | | X | 0 | 13 | High-altitude blue haze over arctic. |

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| TD (UT) | PH | | MH | | EH | | MC | |
|---|---|---|---|---|---|---|---|---|
| | Occurrence | Latitude, ° | Occurrence | Latitude, ° | Occurrence | Latitude, ° | Occurrence | Latitude, ° |
| Mar. 16, 1965 | X | +90 | X | −10, +50 | | | | |
| 17 | X | +90 | X | −10, +30 | X | −35, −65 | X | −10, +30 |
| 18 | X X | −90, +90 | X | 0, +30 | X | −3, +90 | | |
| 19 | X X | −90, +90 | X | −10, +40 | | | | |
| 20 | X X | −90, +90 | | | | | X | +20 |
| 21 | X X | −90, +90 | | | | | | |
| 23 | X | +90 | | | | | X | +15 |
| 26 | X | +90 | | | | | | |
| 27 | X X | −90, +90 | | | | | X | +25 |
| 28 | X X | −90, +90 | | | | | X | +20 |
| 29 | X | −90 | X | −10, +10 | | | | |
| 30 | X | −90 | | | | | | |
| 31 | X X | −90, +90 | X | −10, +10 | X | −15, +35 | | |
| Apr. 1 | X | +90 | X | +10, +45 | | | | |
| 16 | X | −90 | | | | | X | −10, +58 |
| 17 | X | −90 | X | −35, +55 | X | −90, +40 | | |
| 19 | X | −90 | X | +30, +45 | X | −90, +50 | X | 0 |
| 20 | X | −90 | X | −10, +25 | X | −90, +90 | | |
| 21 | X X | −90, +90 | | | X | −90, +90 | X | +10 |
| 23 | X | −90 | X | 0, +32 | X | −90, +90 | | |
| 24 | X X | −90, +90 | | | X | −90, +90 | | |
| 27 | X | −90 | | | X | −90, +90 | X | 0 |
| 28 | X | +90 | | | X | −90, +90 | X | 0 |
| 29 | X X | −90, +90 | | | X | +10, +35 | | |
| 30 | X | +90 | X | −10, +22 | X | −10, +22 | X | −10, +35 |
| May 1 | X | +90 | X | −2, +30 | | | | |
| 2 | X X | −90, +90 | X | +10, +35 | | | | |
| 6 | | | | | | | | |
| 7 | X | +90 | X | −3, +38 | | | | |
| 9 | X | +90 | | | X | −15, +60 | | |
| 10 | X | +90 | | | X | −15, +60 | | |
| 16 | X | −90 | | | | | | |
| 17 | X | −90 | | | | | X | +25 |
| 20 | | | X | −5, +55 | | | | |
| 28 | | | | | X | 0, +50 | | |
| 30 | X X | −90, +90 | X | 0, +90 | | | X | +10 |
| 31 | X X | −90, +90 | X | 0, +90 | | | X | +10 |

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**Table 4 (Cont'd)**

| | EC | | | CB | | MD | Remarks |
|---|---|---|---|---|---|---|---|
| Longitude, ° | Occurrence | Latitude, ° | Longitude, ° | Occurrence | Latitude, ° | | |
| | X | −40, +20 | 220, 280 | X | 0 | 14 June | High-altitude blue haze over arctic, Hellas. |
| 15, 60 | X | 0, +30 | | X | 0 | 14 | |
| | X | +20 | 235 | X | 0 | 15 | |
| | X | +30 | 320 | X | 0 | 15 | |
| 335 | X | +25 | 215 | | | 16 | |
| | X | +5 | 215 | | | 16 | |
| 5 | X | +20 | 215 | | | 17 | |
| | X | 0 | 200 | | | 19 | |
| 280 | X | 0, +40 | 140, 220 | | | 19 | Recurrent clouds E and F. |
| 300 | X | 0, +40 | 140, 220 | | | 19 | Recurrent clouds E and F. |
| | X | 0, +25 | 161, 220 | | | 20 | Recurrent clouds E and F. |
| | X | 0, +35 | 147, 235 | | | 20 | Recurrent clouds E and F. |
| | X | 0, +58 | 122, 235 | X | 0 | 21 | Recurrent clouds B, E, F, and G. |
| | X | 0, +58 | 122, 235 | | | 21 | Recurrent clouds B, E, F, and G. |
| 45, 110 | X | +25 | 340 | | | 28 | |
| | X | +35 | 320 | X | 0 | 29 | |
| 90 | X | +35 | 320 | X | 0 | 30 | |
| | X | +25 | 335 | X | +10 | 30 | |
| 70 | X | +33 | 323 | X | +10 | 1 July | |
| | X | +25 | 275 | | | 2 | |
| | X | +25 | 275 | | | 2 | |
| 0 | X | 0 | 230 | | | 4 | |
| 0 | X | 0 | 230 | | | 4 | |
| | X | +30 | 280 | | | 4–5 | |
| 270 | | | | | | 5 | |
| | X | 0 | 200 | | | 5 | |
| | X | +22 | 210 | | | 6 | South polar hood suspected. |
| | X | +22 | 210 | X | 0 | 8 | |
| | X | +22 | 210 | X | 0 | 8 | |
| | | | | | | 9 | |
| | | | | | | 10 | |
| | X | +20 | 95 | | | 13 | |
| 180 | X | 0 | 65 | | | 13 | |
| | X | +10 | 35 | | | 14 | |
| | | | | | | 18 | |
| 100 | X | +25 | 310 | | | 19 | |
| 100 | X | +25 | 310 | | | 20 | |



2

Table 4 (Cont'd)

| TD (UT) | PH | | MH | | EH | | MC | | |
|---|---|---|---|---|---|---|---|---|---|
| | Occurrence | Latitude, ° | Occurrence | Latitude, ° | Occurrence | Latitude, ° | Occurrence | Latitude, ° | Longitude, ° |
| June 1, 1965 | X | +90 | | | | | | | |
| 2 | | | | | X | −10, +45 | | | |
| 6 | | | | | | | | | |
| 7 | | | | | | | | | |
| 9 | X | −90 | | | | | | | |
| 10 | | | X | 0, +20 | | | | | |
| 11 | X | −90 | | | | | | | |
| 12 | | | | | | | | | |
| 13 | | | | | | | | | |
| 15 | | | X | −10, +30 | | | | | |
| 17 | | | | | | | | | |
| 18 | | | | | X | −10, +30 | | | |
| 19 | | | | | | | | | |
| 20 | | | | | | | | | |
| 21 | | | | | | | | | |
| 23 | | | X | −30, +35 | | | | | |
| 25 | | | | | X | −15, +25 | X | 0 | 170 |
| 26 | X | −90 | | | X | −10, +28 | X | 0 | 167 |
| 27 | X | −90 | | | X | −40, +50 | X | +25 | 135 |
| 28 | X X | −90, +90 | | | X | −90, +90 | X | +20 | 140 |
| 29 | | | | | X | −40, +70 | X | +8 | 125 |
| 30 | | | | | | | X | −20 | 90 |
| July 2 | | | | | | | | | |
| 8 | | | | | | | | | |
| 9 | | | | | | | | | |
| 10 | | | | | | | | | |
| 11 | | | | | | | | | |
| 13 | X | +90 | | | | | | | |
| 15 | X | +90 | | | | | | | |
| 16 | X | +90 | | | X | −10, +10 | | | |
| 19 | X | +90 | | | X | −55, +20 | | | |
| 20 | X | +90 | | | X | −55, +20 | | | |
| 21 | X | −90 | | | X | +10, +60 | | | |
| Aug. 25 | X | +90 | | | | | | | |
| Oct. 12 | X | −90 | | | | | X | −5 | 160 |

| EC | | | CB | | MD | Remarks |
|---|---|---|---|---|---|---|
| currence | Latitude, ° | Longitude, ° | Occurrence | Latitude, ° | | |
| | | | | | 20 July | |
| | | | | | 21 | |
| X | +20 | 235 | | | 23 | |
| X | +20 | 235 | | | 23 | |
| | | | | | 24 | |
| | | | | | 25 | |
| | | | | | 25 | |
| X | −45 | 180 | | | 26 | |
| X | −25 | 165 | | | 26 | |
| X | +10 | 130 | | | 27 | |
| X | +10 | 100 | | | 28 | Recurrent cloud. |
| X | +8 | 100 | | | 29 | Recurrent cloud. |
| X | +10 | 100 | | | 29 | Recurrent cloud. |
| X | +8 | 90 | | | 30 | Recurrent cloud. |
| X | 0 | 95 | | | 30 | Recurrent clouds. |
| X | −5 | 115 | | | 31 | Medium- and high-altitude cloud concentrations. |
| | | | | | 1 Aug. | |
| | | | | | 2 | |
| | | | | | 2 | |
| X | 0 | 350 | | | 3 | |
| | | | | | 3 | |
| X | +5 | 350 | | | 4 | |
| X | +20 | 310 | | | 5 | |
| X | +25 | 215 | | | 8 | Recurrent cloud. |
| X | +20 | 260 | | | 9 | |
| X | +20 | 260 | | | 9 | |
| X | +10 | 245 | | | 10 | Tenuous evening cloud. |
| | | | | | 11 | Tenuous arctic haze. |
| X | 0 | 195 | | | 12 | Large recurrent cloud. |
| X | +25 | 220 | | | 12 | Tenuous arctic haze; recurrent cloud. |
| | | | | | 14 | Tenuous arctic haze. |
| | | | | | 14 | Tenuous arctic haze. |
| | | | | | 15 | |
| X | −10 | 155 | | | 3 Sept. | Tenuous arctic haze. |
| | | | | | 1 Oct. | |

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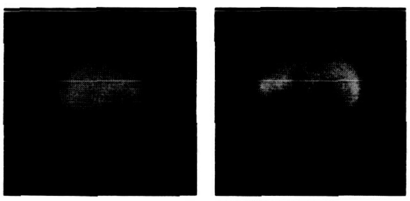
short, broad feature extending out from the terminator about 25 areocentric degrees. During the appearance of the streak no cloud concentrations were noted in violet or blue light. The frequency and occurrence in blue, violet, and ultraviolet light of these fine-lined atmospheric features are not known.

### E. Atmospheric Green Opacity

The yellow-green pass-band (W-57, GG-14, or VG-10) is normally used in Mars observation to explore interesting surface features in this light, while effectively penetrating the Martian atmosphere (Fig. 20); and for color cross-checking in tricolor colorimetry. Surface frost patches are enhanced and many dark features are enlarged and extended for study in green light.



| A | B |
|---|---|
| 65 02 27 YG | 65 02 27 B |
| CM 133° | CM 135° |
| MD 6 June | MD 6 June |

**Fig. 20. Comparison of clouds in yellow-green light (photograph A) and in blue light (photograph B)**

Five dense cloud concentrations and general atmospheric haze were photographed in yellow-green light on the nights of February 25 through March 9 TD in the areographic longitudes from 90° to 200°, which coincided with the blue-type cloud activity. Yellow-green light has been relied upon to penetrate the Martian atmosphere and record the bright white and dark surface features or the yellow dust clouds. The combination of higher-level blue-type clouds and an opaque atmosphere in the yellow-green region is a rather unusual phenomenon, indeed.

A thorough study of the photographs obtained from January through May showed that the "green-haze" was chiefly confined to the areographic longitudes of 80° to 265°. The Syrtis Major, at 290° longitude, appeared only slightly hazy in green light; while the Nodii Laocoontis–Alcyonius, and the Trivium Charontis, east of the grand Thoth canal, were recorded very poorly in yellow-green light. The atmospheric opacity appeared identical in blue-green light and in broad blue light. The coincident blue and yellow-green five cloud concentrations were measured at the following center-of-area positions: Cloud A) 95°, +12°; Cloud B) 136°, +19°; Cloud C) 117°, +46°; Cloud D) 111°, +15°; Cloud E) 161°, +02°. These five cloud formations became large, diffuse, and connected in yellow-green light relative to the bright and sharply defined blue clouds. The yellow-green photographs showed more haze between the cloud concentrations; and a dense, complete haze resided in the southern hemisphere. There were other smaller and weaker cloud concentrations also noted on the blue and violet photographs of Mars (Fig. 20).

Figure 21 graphs the opacity of the "green-haze" in an arbitrary 3-unit scale. Atmospheric green opacity was first recorded weakly on green photographs on February 18 TD. Strong to moderate "green haze" existed throughout the period February 20 to March 16 TD. The atmosphere began to clear in the yellow-green region during April and May TD, and the "green-haze" was not seen again during the apparition in the 80° to 270° longitudes.

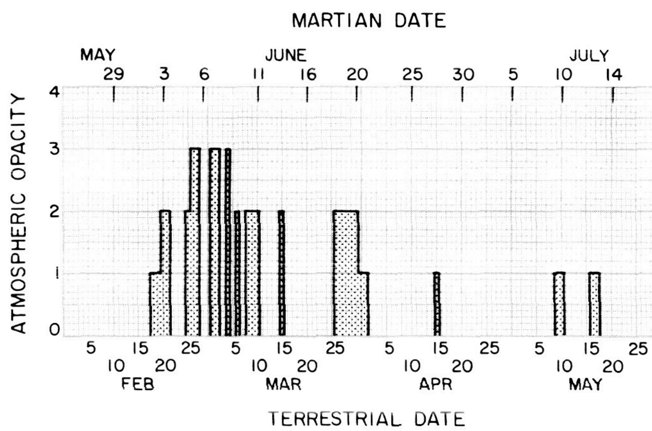



**Fig. 21. "Green-haze" phenomena, 80° to 260° longitude**

### F. Atmospheric Violet Opacity and Blue-Clearing

The Martian atmosphere is normally opaque to violet and ultraviolet light with wavelengths shorter than 4550A. Photographs of Mars in violet and ultraviolet light normally show only the atmosphere itself and bright cloud formations above the surface (Fig. 22). Broad pass-band blue photographs will penetrate the atmosphere in varying degrees to the Martian surface depending upon the amount of cloud and haze, and occasionally show vaguely the dark maria.

When the curious phenomenon of atmospheric blue-clearing occurs, violet photographs show the gross dark maria in varying degrees of definition; and blue photographic definition of surface details is always improved.

Ultraviolet-light photographs have been known to record gross and dark surface features during periods of strong blue-clearing. Blue-clearing can be general and encompass an entire hemisphere, or it can be quite localized, a fact which can be seen from Table 5. A brief historical description of blue-clearing can be found in Sec. III.

The reason for the variable atmospheric opacity is still highly speculative because of the present state of knowledge. For the past decade, statistical evidence indicated that the occurrence of the blue-clearing phenomenon was dependent upon the conditions found around the time of opposition. However, strong blue-clearings have been recorded 60 to 70 days from opposition at Lowell Observatory (Ref. 2); and more recently, 166 days and again 72 days from opposition at Table Mountain. Statistically, more blue-clearings have been recorded around the time of opposition because more observations have been acquired when physical observing conditions are at their maximum. Consequently, the geometrical and physical parameters associated with the opposition position are not criteria for predicting periods of blue-clearing.

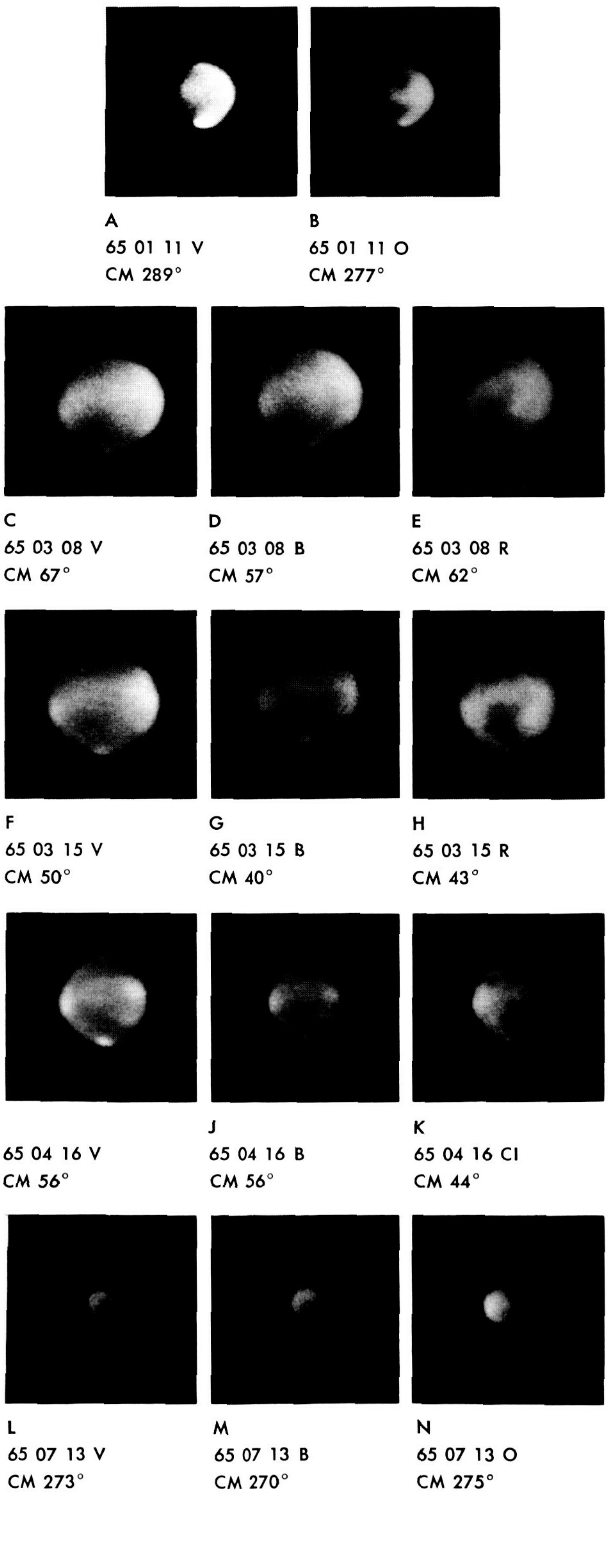



**Fig. 22. Five periods of atmospheric blue clearing during the 1964–1965 apparition; the photographic set A and B is one of the early preopposition periods of blue clearing, with the light from the Boreosyrtis region penetrating the northern Martian atmosphere, and part of the Mare Iapygia and Syrtis Major showing weakly in the south; image A was exposed in violet light; and for surface feature comparison, only image B is in orange light; the photographic series C, D, and E shows a well defined northern hemisphere blue-clearing period during opposition, with the dark Mare Acidalium penetrating the atmosphere; series F, G, and H is another example of a northern hemisphere blue-clearing in violet and blue light, with a surface feature comparison image in red light; photographic series I, J, and K is a general atmospheric blue clearing with both the southern and northern maria showing through the Martian atmosphere; the last images, L, M, and N, are remarkable in that they were obtained about 32 degrees above the horizon with a planetary disk diameter of 6″.5 of arc and 126 days past opposition; the violet and blue images, L and M, recorded no cloud activity and the Boreosyrtis–Casius Wedge shows through the atmosphere in the north**

**Table 5. Blue-clearing phenomena**

| TD (UT) | 0 ? 1 Weak 2 Medium 3 Strong | Location | Feature | Ls, ° | MD | Observer | Atmospheric activity |
|---|---|---|---|---|---|---|---|
| Sept. 26, 1964 | 2 | North central | Thoth, Casius | 6 | 27 Mar. | C. Capen J. Young | Terminator cloud; weak morning limb haze; weak south polar hood. |
| Sept. 27 | 2 | Extrapolated | | 7 | 27 Mar. | | |
| Sept. 28 | 2 | Northern hemisphere | Thoth, Gyndes | 7 | 28 Mar. | C. Capen V. Capen | Terminator cloud; general atmospheric clearing; frost area; no limb haze; no polar hoods. |
| Sept. 29 | 1 | Northern hemisphere | Dis–Gyndes Sithonius | 8 | 28 Mar. | C. Capen V. Capen | Atmospheric haze increasing; terminator cloud larger. |
| Sept. 30 | 1 | Subarctic | Propontis Dis–Gyndes | 8 | 29 Mar. | C. Capen | Terminator cloud smaller; afternoon and morning frost areas. |
| Oct. 1 | 1 | Subarctic | Propontis Sithonius Lacus | 9 | 29 Mar. | C. Capen J. Young | Little atmospheric haze; afternoon cloud; morning frost. |
| Oct. 2 | 1 | Extrapolated | | 10 | 30 Mar. | | |
| Oct. 3 | 2 | Northern hemisphere | Propontis Sithonius Lacus | 10 | 30 Mar. | C. Capen | Atmosphere relatively clear; terminator cloud smaller and weaker; morning frost patch. |
| Oct. 4 | 2 | Northern hemisphere | Propontis Gyndes | 10 | 31 Mar. | C. Capen V. Capen | Atmosphere relatively clear; blue-clearing fading; morning frost. |
| Oct. 5 | 1 | Subarctic | Propontis | 11 | 31 Mar. | J. Young | Terminator cloud and haze. |
| Oct. 6 | 1 | Subarctic | Propontis | 11 | 31 Mar. | C. Capen | Increasing clouds and limb haze. |
| Oct. 7 | 1 | Subarctic | Boreum Propontis | 12 | 1 Apr. | C. Capen V. Capen R. Schorn | Large afternoon cloud; morning limb haze; south polar hood. |
| Dec. 6 | 1 | General | Casius, Syrtis | 39 | 29 Apr. | C. Capen | Morning limb haze; weak south polar hood; blue-clearing strongest in north. |
| Dec. 7 | 1 | General | Casius, Syrtis | 40 | 30 Apr. | C. Capen V. Capen | Same as December 6. |
| Dec. 8 | 0 | General | Casius, Syrtis | 40 | 30 Apr. | J. Young | Same as December 6. |
| Dec. 10 | 1 | Northern hemisphere | Panchaia Casius | 41 | 1 May | C. Capen V. Capen | Visible atmospheric moisture increasing; morning limb haze and terminator cloud. |
| Dec. 29 | 1 | Northern hemisphere | Acidalium | 50 | 10 May | J. Young | Atmosphere clear; morning frost. |
| Dec. 30 | 2 | Northern hemisphere | Acidalium Boreum | 50 | 10 May | J. Young | Same as December 29. |
| Dec. 31 | 2 | Extrapolated | | 50 | 11 May | | |
| Jan. 1, 1965 | 2 | Northern hemisphere | Acidalium | 51 | 11 May | J. Young | Morning limb haze and frost. |
| Jan. 2 | 1 | Northern hemisphere | Acidalium | 51 | 11 May | J. Young | Morning limb haze and frost; terminator equatorial cloud. |
| Jan. 11 | 1 | Northern evening hemisphere | Utopia | 55 | 16 May | C. Capen V. Capen | Morning limb haze; Hellas frost. |

**Table 5 (Cont'd)**

| TD (UT) | 0 ? 1 Weak 2 Medium 3 Strong | Location | Feature | Ls, ° | MD | Observer | Atmospheric activity |
|---|---|---|---|---|---|---|---|
| Mar. 8, 1965 | 2 | Northern hemisphere | Acidalium, Boreum | 80 | 10 June | C. Capen V. Capen | Atmosphere generally clear of haze 0° to 90° longitude; weak evening cloud. |
| Mar. 9 | 2 | Northern hemisphere | Acidalium, Boreum | 80 | 11 June | J. Young | Morning cloud. |
| Mar. 10 | 1 | Northern hemisphere | Acidalium, Boreum | 81 | 11 June | V. Capen | Evening cloud; morning limb haze. |
| Mar. 15 | 1 | Northern hemisphere | Acidalium, Boreum | 83 | 13 June | C. Capen | Morning haze and a weak equatorial cloud band. |
| Mar. 16 | 1 | Northern hemisphere | Acidalium | 83 | 14 June | J. Young | Atmosphere generally clear in longitudes 350° to 110°; only limb hazes present. |
| Mar. 30 | 0 | Central | Trivium Propontis | 89 | 20 June | C. Capen J. Young | Three recurrent afternoon clouds; morning frost on Elysium. |
| Mar. 31 | 0 | Central | Trivium Propontis | 90 | 21 June | C. Capen J. Young | |
| Apr. 16 | 1 | General | Acidalium Aurorae S. | 97 | 28 June | C. Capen V. Capen | One evening limb cloud; one sunrise cloud; morning limb haze. |
| Apr. 28 | 0 | Southern hemisphere | Sabaeus, Iapygia | 102 | 4 July | V. Capen | Atmosphere generally clear of haze; one small evening cloud. |
| Apr. 29 | 0 | Southern hemisphere | Sabaeus Iapygia | 103 | 4–5 July | C. Capen | One small evening cloud; arctic haze; atmosphere generally clear. |
| Apr. 30 | 0 | South | Sabaeus Iapygia | 103 | 5 July | C. Capen | One small evening cloud; arctic haze; atmosphere generally clear. |
| May 1 | 0 | Southern hemisphere | Iapygia | 104 | 5 July | C. Capen | One evening cloud; morning weak haze; arctic haze. |
| May 9 | 0 | Northern hemisphere | Propontis Utopia | 107 | 9 July | J. Young | Evening cloud; cloud over Elysium. |
| May 10 | 0 | Northern hemisphere | Propontis Utopia | 108 | 10 July | C. Capen | Small evening cloud; cloud over Elysium. |
| May 11 | 0 | Northern hemisphere | Propontis Utopia | 108 | 10 July | C. Capen | Small evening cloud; weak cloud over Elysium. |
| July 13 | 1 | Northern hemisphere | Casius Utopia | 138 | 11 Aug. | C. Capen V. Capen J. Young | Atmosphere very clear; one small frost patch on Elysium. |
| July 14 | 1 | Extrapolated | | 139 | 11 Aug. | | Seeing too poor for blue-clearing test. |
| July 15 | 1 | Northern hemisphere | Casius Utopia | 139 | 12 Aug. | C. Capen V. Capen | Evening haze and cloud. |
| July 16 | 1 | Northern hemisphere | Casius Utopia | 140 | 12 Aug. | C. Capen V. Capen | Small evening cloud; weak evening haze. |
| July 19 | 1 | Northern hemisphere | Panchaia Utopia | 141 | 14 Aug. | C. Capen V. Capen | Weak evening haze; morning frost; no clouds. |

Recent studies by the author indicate that a correlation may exist between the amount of diurnal visible cloud and seasonal free water vapor and the occurrence of atmospheric blue-clearing. When the atmosphere shows a visible-cloud clearing trend, and becomes extremely clear, there is a resulting blue-clearing period. Whether the blue-clearing is associated with the absence of obscuring clouds and haze or whether it is dependent upon some unknown upper atmospheric scattering phenomenon is for future study to determine.

The results of a thorough survey of all 1964–1965 violet and blue images versus orange or red images are shown in Table 5, which gives periods of blue-clearing in an arbitrary subjective 4-unit scale of atmospheric violet-light transparency versus visible aqueous conditions, Martian seasonal date, and Martian planetocentric longitude of the Sun. In this table, 0) represents suspected but unconfirmed clearing because of poor image quality or complicating dark areas between bright blue clouds that approximately match dark maria positions; 1) weak confirmed blue-clearing; 2) medium blue-clearing; and 3) strong blue-clearing, when violet-light photographs show dark surface details with contrasts that rival orange- or red-light surface details. A histogram of the blue-clearing data versus days from opposition and the Martian date is shown in Fig. 23.

The periods of atmospheric blue-clearing during the 1964–1965 apparition were scarce and rather weak; only seven clearings were confirmed. The first observed blue-clearing was a visual, moderately strong 12-day period that began 166 days before opposition on September 26, 1964. The next clearing was a weak one that occurred 95 days prior to opposition on December 6, 1964, and lasted for about 5 days. Another moderate blue-clearing was noted some 72 days before opposition, which lasted for a 5-day period. Once again a blue-clearing period was observed around the opposition date. About a week before the *Mariner IV* encounter with Mars on July 14 the Martian atmosphere showed a definite clearing trend. By July 12 the Martian atmosphere was observed to be extremely clear of haze and clouds, with only one white frost patch noted on the Elysium. At this time, the last recorded blue-clearing period of the apparition was observed at 126 days past opposition. There were two visually observed blue-clearings on March 30 and 31 and again on May 9 to 11 in the 200° Central Meridian region that could not be confirmed on violet photographs because a bright cloud over the Elysium plateau was contiguous to the below-average-contrast feature of the Trivium Charontis.

The percentage of nights in which some form of blue-clearing was detected was 28.6% of the total nights of violet-blue observations acquired during the 1964–1965 apparition.

### G. White Area Activity

An area survey of surface or near-surface whitenings was obtained from all available integrated, orange, and yellow-green light 1964–1965 data. For the white coverage, 247 separate observations were examined. Figure 24 is a histogram of the white area activity in the northern and southern hemispheres. The ordinate scale defines the number of occurrences of whitening over the period of observation. The terrestrial date versus the Martian date is shown along the abscissa. Hatching indicates periods of no observation.

The histogram indicates moderate frost activity around the time of the vernal equinox, or beginning of the northern hemisphere Martian spring season. The frost activity during this period was largely confined to the southern hemisphere, however, which was changing from its equivalent summer to autumn season. The occurrence of whitened areas during the northern hemisphere early Martian spring season was relatively low. The white area activity increased to a maximum at the end of Martian spring, and remained active until midsummer. It is interesting to compare the seasonal lag of the white area activity with that of the North Polar Cap regression curve shown in Fig. 12.

A list of all white areas that were detected is given in Table 6. The terrestrial date of occurrence, the areographic area name where the whitening was observed, the relative Martian date, and pertinent remarks are listed. This table discloses the fact that whitenings tend to occur on certain areographic areas at defined positions. The white areas are observed on the lighter ocher desert regions and appear with sharp, well defined borders when contiguous to dark surface features. The percent of the number of days of observed whitenings relative to the number of days of observational coverage is 65.6%, which seems surprisingly high. What percent is actual surface "frost" and what is ground "ice-fog" type phenomena are, of course, unknown. It remains to be shown conclusively that the white areas are associated with the detected $H_2O$, or whether they are composed of $CO_2$ or a combination of $H_2O$ and $CO_2$.

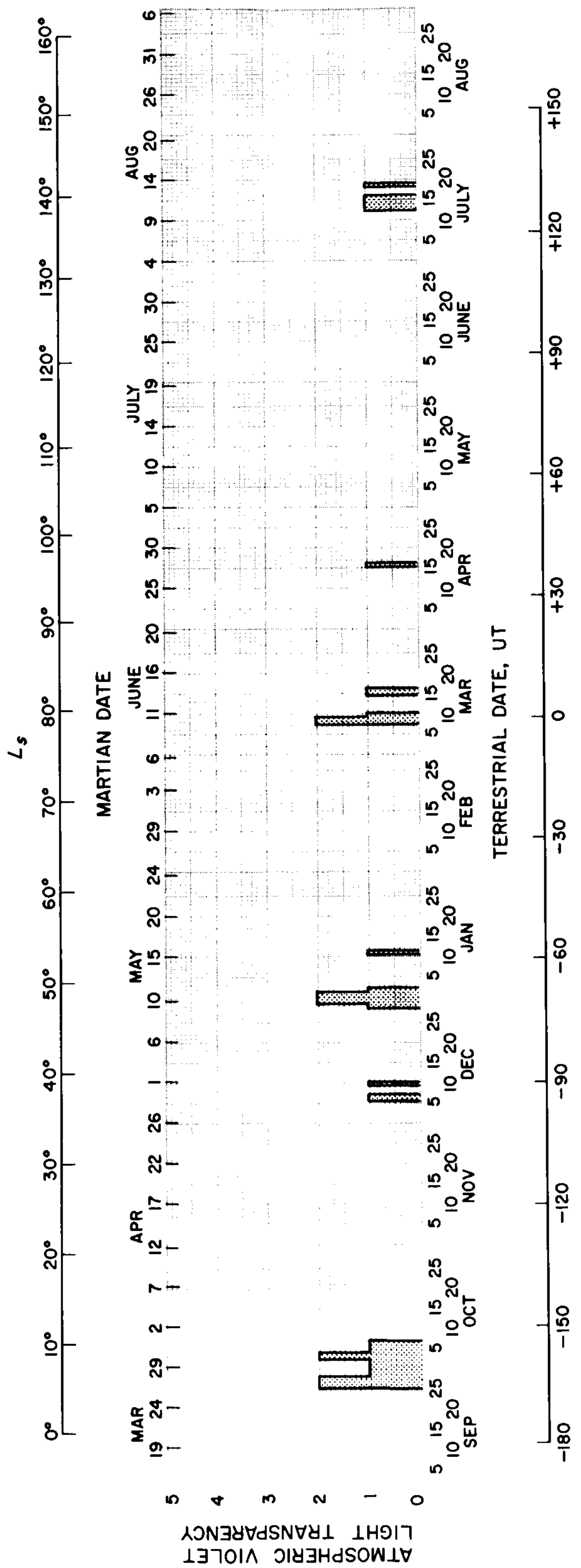



**Fig. 23. Blue-clearing phenomena histogram**

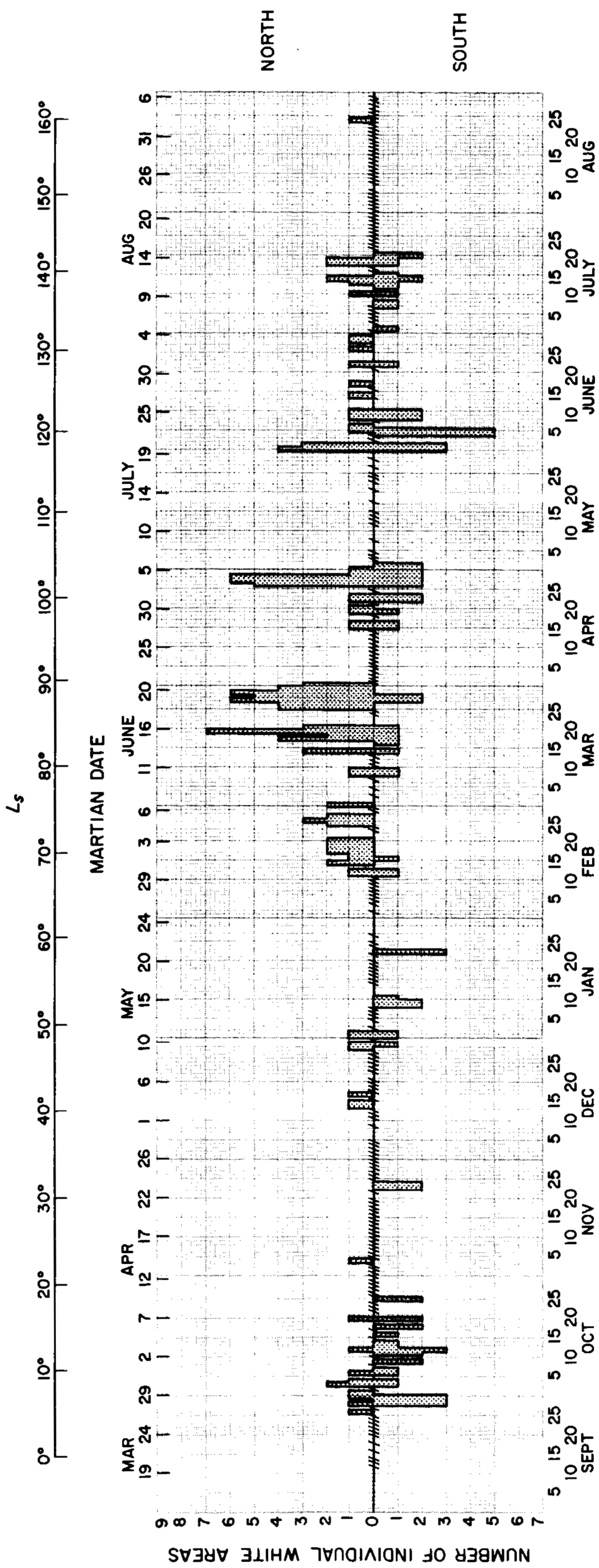



**Fig. 24. White area activity**

**Table 6. White areas**

| TD | Location | MD | Remarks |
|---|---|---|---|
| Sept. 26, 1964 | Albor; Elysium? | 27 Mar. | Gray white. |
| 28 | Electris–Eridania; Isidis Regio; Mesogaea | 28 | White. |
| 29 | Electris and Eridania light areas, just south of Mare Cimmerium, 155° long., −5° lat. (Saus) | 28 | |
| 30 | Electris and Eridania; Eumenides; Isidis Regio | 29 | |
| Oct. 1 | Isidis Regio | 29 | |
| 3 | Aethiopis–Isidis Regio deserts | 30 | |
| 4 | Aethiopis desert | 31 | |
| 6 | Elysium plateau or Zephyria desert | 31 | |
| 7 | Zephyria desert | 1 Apr. | |
| 9 | Zephyria–Mesogaea desert | 2 | Bright frost patch. |
| 11 | Zephyria–Mesogaea desert | 3 | Frost patch since Sept. 28. |
| 12 | Zephyria–Mesogaea desert; Chryse desert | 3 | Frost patches |
| 13 | Mesogaea desert | 4 | Frost patch or ice-fog. |
| 14 | Tharsis desert beneath Martian Eye of the Thaumasia–Solis Lacus–Coprates region | 4 | Frost or ice-fog. |
| 16 | Tharsis desert | 5 | Bright frost area. |
| 18 | Candor–Tharsis desert below Martian Eye of the Solis Lacus and contiguous to the Coprates complex | 6 | Frost or ice-fog. |
| 20 | On the equator in the Candor–Tharsis desert region below the Martian Eye | 7 | Frost patch or ice-fog. |
| 25 | Aram; Argyre | 10 | Frost patch or ice-fog; same brightness. |
| Nov. 4 | Across the Wedge-of-Casius covering the Neith Regio | 14 | Early morning frost or ice-fog. |
| 23 | Candor–Tharsis desert | 23 | Ice-fog or frost. |
| 24 | Candor–Tharsis desert | 24 | Ice-fog or frost. |
| Dec. 14 | Isidis Regio | 3 May | Morning-limb white frost. |
| 15 | Isidis Regio | 3 | |
| 17 | Isidis Regio or Aethiopis | 4 | |
| 29 | North of the Equator on the Candor desert just below the Martian Eye | 10 | Frost patch. |
| 30 | Tharsis | 10 | Frost or ice-fog. |
| Jan. 1, 1965 | Tharsis–Candor | 11 | Frost or ice-fog. |
| 2 | Aram; Nix Tanaica? | 11 | Frost or ice-fog. |
| 9 | Aram; Hellas plateau just south of Syrtis | 15 | Hellas not as bright as North Cap. |
| 10 | Hellas; Noachis region | 15 | Hellas ice-fog or frost. |
| 11 | Hellas | 15–16 | |
| 23 | Phaethontis, Electris, Eridania | 21 | Frost suspected. |

**Table 6 (Cont'd)**

| TD | Location | MD | Remarks |
|---|---|---|---|
| Feb. 12, 1965 | Equator on the Aram | 30 May | Frost or ice-fog. |
| 13 | Aram area | 31 | Frost or ice-fog. |
| 15 | Isidis Regio, Nix Cydonia | 1 June | |
| 16 | Aram; Hellas | 1 | Bright spot on Hellas. |
| 17 | North part of the Elysium | 1 | |
| 18 | Entire Elysium | 2 | Brilliant white. |
| 19 | Entire Elysium | 2 | Brilliant white. |
| 20 | Entire Elysium | 3 | Brilliant white. |
| 21 | Elysium | 3 | |
| 25 | Elysium | 5 | |
| 26 | Elysium; Neith Regio desert | 5–6 | Elysium brighter than North Cap. |
| 27 | Elysium | 6 | |
| Mar. 1 | Elysium plateau | 7 | |
| 9 | Edom area | 11 | Frost or ice fog. |
| 10 | Near the Equator on the Tharsis desert; Aram? | 11 | |
| 15 | Aram; Aeria; Nix Cydonia; Noachis? | 13 | |
| 17 | Hellas plateau | 14 | |
| 18 | Elysium; Hellas; Oxia—Cydonia desert adjacent to the eastern border of the Acidalium | 15 | Oxia–Cydonia frost or ice-fog. |
| 19 | Hellas plateau; part of the Aeria desert and the Nymphaeum area | 16 | Nymphaeum area yellow-white. |
| 20 | Hellas; Elysium; Aeria desert; Isidis and Neith Regios; Eden desert | 16 | Bright frost on Aeria desert. |
| 21 | Hellas; Elysium; Nix Cydonia | 16 | |
| 23 | Elysium; Eden–Aram deserts Neith–Isidis Regio and Nymphaeum plateau; Hellas plateau; arctic | 17 | Hellas brilliant white. |
| 26 | Elysium; Neith Regio; arctic | 19 | |
| 27 | Amazonis desert; Neith Regio; Elysium | 19 | |
| 28 | Aeria desert and along Cenotria–Crocea areas; Libya desert, Neith Regio; Elysium plateau | 19 | Libya–Cenotria–Crocea frost or ice-fog. |
| 29 | Libya, Crocea, Cenotria and Aeria deserts; arctic; Elysium? | 20 | Elysium lighter in shade than surrounding ocher deserts, but not pure white. |
| 30 | Elysium; Arcadia desert; Wedge-of-Casius in Utopia region; Phlegra; arctic | 20 | Elysium brighter than North Cap. |
| 31 | Elysium; arctic; Phlegra | 21 | Elysium brighter than North Cap. |
| Apr. 1 | Elysium; Neith Regio | 21 | |
| 16 | Argyre; Nix Tanaica in Tempe desert | 28 | |
| 17 | Argyre; Nix Tanaica in Tempe desert | 29 | |
| 20 | Tharsis desert | 30 | Bright frost patch or ice-fog. |
| 21 | Candor desert | 1 July | |
| 23 | Hellas plateau; arctic | 2 | Hellas brighter than North Cap. |
| 24 | Hellas plateau; arctic | 2 | Hellas brighter than North Cap. |
| 27 | Hellas, Aeria desert, Neith–Isidis Regio and Elysium | 4 | Hellas brighter than North Cap. |

**Table 6 (Cont'd)**

| TD | Location | MD | Remarks |
|---|---|---|---|
| Apr. 28, 1965 | Aeria desert, Neith–Isidis Regio, and Elysium plateau; Hellas to the south polar region; arctic | 4 July | Hellas brighter than North Cap. |
| 29 | Oxia; Hellas, Isidis Regio, Neith Regio, Nymphaeum, Aeria desert; arctic (0° to 25° long.) | 4–5 | South edge of North Cap as bright as Hellas plateau. |
| 30 | Hellas; Elysium | 5 | South edge of North Cap as bright as Hellas plateau; Hellas brighter than North Cap. |
| May 1 | Hellas; Elysium | 5 | South edge of North Cap as bright as Hellas plateau; Hellas brighter than North Cap. |
| 2 | Hellas | 6 | Hellas not as bright as on Apr. 29–May 1; not as bright but larger than North Cap. |
| June 1 | Hellas plateau; antarctic; northern tip of Mare Syrtis covering half of Isidis–Neith Regios; Aeria desert in Nymphaeum; Nix Cydonia on eastern border of Acidalium; Noachis. | 20 | |
| 2 | Antarctic; Hellas; Isidis Regio, Neith Regio; Nilosyrtis canal into Meroe Insulae | 21 | |
| 5 | Antarctic, Ausonia, Hellas, Noachis | 22 | Brighter than North Cap. |
| 6 | Antarctic, Ausonia, Hellas, Noachis; Isidis Regio | 23 | Not as bright as on June 5. |
| 7 | Isidis Regio | 23 | |
| 9 | Hellas; Elysium plateau | 24 | North Cap brighter than Hellas. |
| 10 | Hellas; Elysium plateau | 25 | North Cap brighter than Hellas. |
| 11 | Hellas; Elysium plateau | 25 | North Cap brighter than Hellas. |
| 15 | Elysium plateau | 27 | |
| 18 | Terminator on Elysium plateau | 29 | |
| 23 | Antarctic; Elysium | 31 | Elysium frost suspected. |
| 27 | Nix Cydonia area in Cydonia desert | 2 Aug. | |
| 29 | Nix Cydonia area in Cydonia desert | 3 | |
| 30 | Nix Tanaica | 4 | |
| July 2 | Noachis | 5 | Appeared as a pseudo south cap. |
| 8 | Hellas plateau | 8 | Appeared as a pseudo south cap. |
| 9 | Hellas | 9 | Not as bright as North Cap. |
| 11 | Hellas plateau; Elysium | 10 | Not as bright as North Cap. |
| 13 | Hellas plateau | 11 | |
| 14 | Elysium area | 11 | |
| 15 | Antarctic; Hellas plateau; Aeria and Nymphaeum | 12 | |
| 16 | Hellas | 12 | |
| 19 | Hellas; Isidis and Neith Regios | 14 | Hellas appeared as a pseudo cap. |
| 20 | Hellas; Isidis and Neith Regios | 14 | Hellas appeared as a pseudo cap. |
| 21 | Isidis and Neith Regios | 15 | |
| Aug. 25 | Amazonis desert | 3 Sept. | At recurrent cloud position. |

# IX. MARTIAN SURFACE FEATURES

When the bright orange disk of Mars is observed by an inexperienced observer for the first time, only vague dusky features, variance of area contrasts, and a possible limb brightening are discerned. In fact, the neophyte can identify fewer surface features than can be obtained on photographs. Given patience and experience, the observer can distinguish the gross dark maria, the bright ocher desert regions, the bright white areas—even the canal-like features become obvious during the Martian spring season. Light spots consisting of off-white or light yellow areas are located at static positions in several ocher desert regions. After the arrival of the "darkening-wave," critical observation reveals variegated shades and intensely dark nodules within the maria themselves. Fine canal structure is observed to traverse the light ocher regions and connect the dark nodules, called oases.

A canal-like feature is a dark linear surface structure believed to be composed of smaller irregular dark fragments close to or below the customary defined telescopic resolution. Some canals become double entities during the Martian early summer season.

## A. Summertime in the Acidalium Region and a Modern Canal Structure

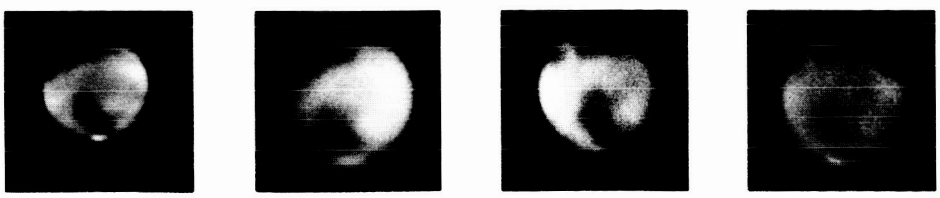
The champion of the northern hemisphere, the Mare Acidalium, was especially well positioned for observational study because the north polar axis was tilted more than 20° toward the Earth for nine terrestrial months during the 1964–1965 apparition. The favorable northern Martian hemisphere observing conditions allowed quality colorimetry and areographic measurements in this usually poorly observed region.

The Mare Acidalium changed from its winter shades of variegated gray and brown to its spring coloration of dark gray and blue-gray shades with gray-green oases concentrations during the latter part of Martian May. In Martian late spring and early summer the Acidalium appeared large and swollen and became a very dark gray general shade with a black-green central area and large dark gray-green oases. By 13 June MD there were many more small dark green oases observed within the Acidalium region than had been identified on existing charts of Mars.

The Mare Acidalium has been progressively increasing in contrast and in longitude width during the last thirty years. The Table Mountain Observatory recorded the Acidalium in 1965 (28 June MD) larger than it appeared in 1963, and larger than in 1918 and 1935 at the Lowell Observatory (Fig. 25).

At the south end, or head, of the Acidalium, the Niliacus Lacus consisted of six dark green oases: three temporary and unmapped Fons and the Endor, the Engedii, and the Jordanis Fons. The Achillis Fons, within the adjoining Nilokeras I canal, appeared as a swollen dark gray oasis in tune with the seasonal darkening wave. Within the Mare Acidalium, itself, the black-green Novem Fons, Acadinius Fons, and Acidalius Fons were the largest and darkest of the oases. Several temporary, smaller, unnamed oases concentrations were located across the southern top border of the Acidalium.

Dark canal structure became evident within the Mare Acidalium in early Martian summer. A narrow canal was



| A | B | C | D |
|---|---|---|---|
| 35 04 20 Y | 63 01 17 R | 65 04 16 R | 65 04 16 G |
| CM 53° | CM 41° | CM 58° | CM 66° |
| MD 17 July | MD 29 April | MD 28 June | MD 28 June |
| Lowell Obs. | TMO. | TMO. | TMO. |

**Fig. 25. Secular changes in the Mare Acidalium region, 1935–1965**

seen traversing the breadth of the Acidalium between oases junctions of the Acidalius Fons and a temporary small, dark oasis at the far southeast corner of the Mare. The Gehon II canal entered this temporary oasis from the southeast. A rather broad canal crossed the Mare from the Novem Fons to the Acidalius Fons. The Tanais canal appeared to branch off and run into the Mare proper, and it was observed to connect with the middle of the Niliacus Lacus and ended at an oasis near the Engedii Fons.

A new or modern surface feature has been gradually developing during the past fourteen years in the Tempe desert and parallel to the following border of the Acidalium. This germinating feature was independently recorded during the 1952 and 1954 apparitions as an insignificant visual darkening in the Tempe desert about ten degrees west of the Acidalium border by S. Ebizawa, T. Cave, and C. Capen. In 1954 (12 August MD) it was observed by the writer, with the aid of the Lowell 24-inch refractor, as a low-contrast streak connecting the Acidalius Fons to the Achillis Fons. By 19 September MD it had lost much contrast and became disconnected from the Achillis Fons. The dusky feature was again seen during the 1962–1963 aphelic opposition, when it was photographed in color and in red light at Table Mountain during the Martian spring season and recognized as a canal structure. During the 1964–1965 apparition the canal-like feature was seen to broaden and darken in contrast in late Martian spring to become an obvious photographic feature. Surprisingly, green light photographs recorded this feature best; although it was recorded fairly well in orange and red light (Fig. 25C and D).

Research through ancient and modern maps of Mars has been made covering the years 1659–1961. The nearest canal to the modern feature is the Issedon registered on the 1890 map by G. Schiaparelli and the 1929 map by D. M. Antoniadi. However, the Issedon's direction averages straight north to south connecting the ancient oasis Labeatis Lacus with the Lunae Lacus, some 25° to the west of the Mare Acidalium, whereas the new feature curves from northwest to southeast and is located about 10° from the western edge of the Acidalium. The conclusion is that the modern canal feature was not registered on historical maps of Mars. The new canal vaguely appears as an unnamed feature on only one modern Mars map drawn by Siro Ebizawa of Tokyo in 1956, which is an updated version of Antoniadi's 1929 map. For the sake of nomenclature this feature has been referred to as the Tempes canal in this Report (Fig. 26).

The western border of the Mare Acidalium will be watched with interest by students of Mars because the narrow strip of desert between the Acidalium border and the Tempes canal may also become filled in during subsequent spring seasons and completely change the position of the western border of the Acidalium.

Note this feature on the green, orange, and red photographs for the following dates: March 8, March 15, April 16, and April 20 in Sec. XI.

### B. *The Great Martian Desert Region—An Areographic Puzzle?*

The great ocher colored expanse of the Tharsis–Tempe–Arcadia–Amazonis desert from 70° to 190° areographic longitude comprise what is known to the student of Mars as the "hard-seeing-side" of Mars. It is a region with a history of frequent atmospheric blue-white and yellow cloud activity. Only low-contrast canal structure connecting the infrequent oases positions has been recorded on the surface.

No surface detail was recorded in the heart of the Great Martian Desert region during the Martian spring season of the 1964–1965 apparition. A rather dense yellow-green haze covered the region during February, March, and most of April, 1965. The atmospheric "green-haze" may have been the observed photographic aftereffect of a bright yellow dust cloud seen in the Amazonis desert during January 29 through February 4, 1965, that was reported to the Lowell Observatory by the veteran Mars observer, T. Cave. Recurrent afternoon clouds were active over the deserts from January through April, 1965. Three recurrent clouds were observed in violet, blue, and yellow-green light at the following measured ca. positions: 110°, +14°; 136°, +19°; 117°, +43°; 88°, +10°. This recurrent cloud activity is suggestive of topographic influence at the indicated dashed-line positions in Fig. 27.

Surface features were first observed traversing the desert region the last of Martian spring. The scarce oases and canal-like features became quite broad with medium to low gray contrasts during Martian summer. The Ascraeus–Pavonis–Lovis Lacii, Biblis Fons, Phrygius Lacus, and Maeotis Palus were large dark gray oases. The gray Mareotis Lacus, Arsenius Lacus, Ascuris Lacus, Arsia Silva, and Nodus Gordii were secondary oases features. The Mare Boreum and Scandia area, at the north border, showed a high-contrast black-green and blue-black seasonal development. The canal structure that was recorded traversing the Great Martian Desert

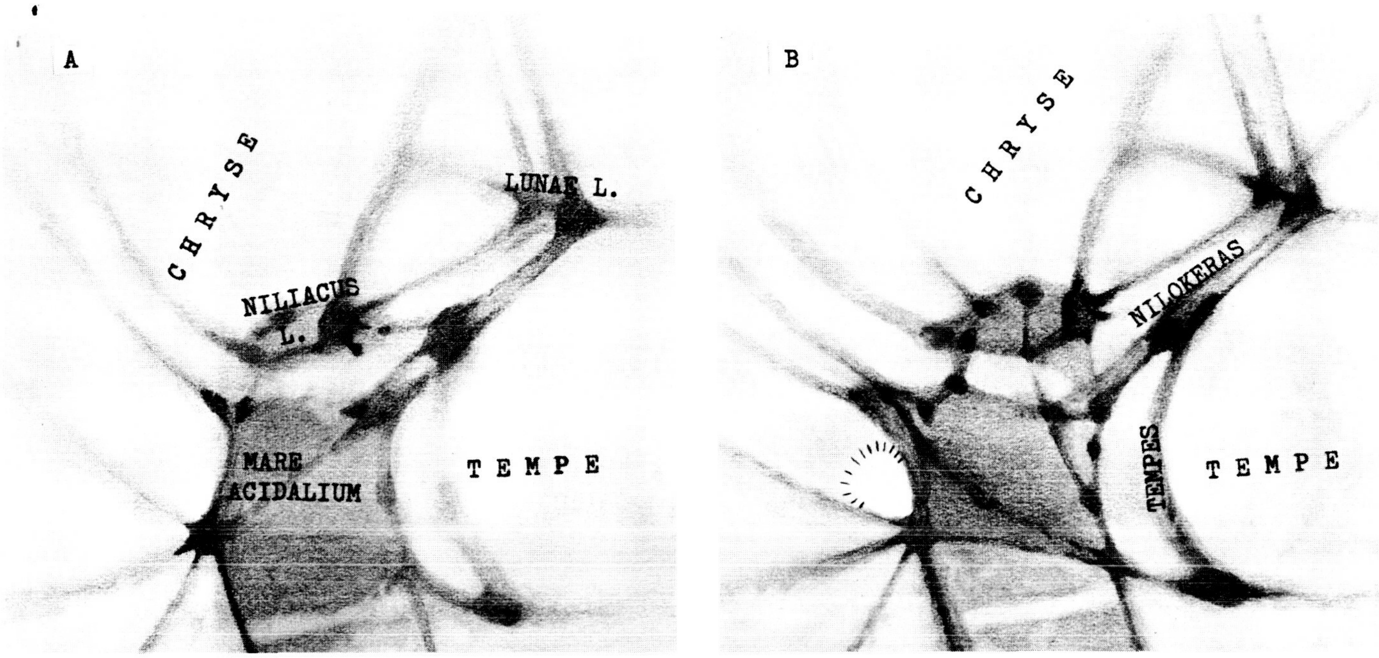



**Fig. 26. Two summer season drawings of the Mare Acidalium showing secular changes over the past eleven years; drawing A was made with the aid of the Lowell Observatory 24-inch refractor, and shows the 1954 aspect of the Mare Acidalium, the Niliacus Lacus, and the dark structure forming on the following west side of the Acidalium in the Tempe desert; drawing B was made with the Gilbert USGS 30-inch Cassegrain reflector, and gives the 1965 appearance of the Mare Acidalium region**

Region follows: Hebrus, Rhyndacus, Gyndes, Ilissus, Eurotus, Aesacus, Bidis, Midas, Athos, Eleus, Fevos, Hades I, Erebus, Titan II, Orcus, Eumenides, Pyriphlegethon, Ceraunius, Gigas, Ulysses, Tartarus, Nilus, Phlegethon, and several unidentified canals.

Much confusion exists in this region because of the atmospheric hazes, low contrast of the few surface features, and the difficult aphelic observing conditions under which it is best studied. The elusive surface features are shown in Fig. 27.

## C. The Propontis Complex

The Propontis complex is composed of four large dark oases that form a rectangular figure from connecting canal-like structures in the northwestern part of the Great Martian Desert region, Arcadia, Amazonis, and Phlegra, at the areographic coordinates 165° longitude, +48° latitude ca. This simple geometrical figure developed into a highly complex one in late Martian spring and early summer. The whole Propontis region appeared abnormal and could not be readily recognized except by careful center-of-area positional measurements of the dark and swollen oases. Measurements of positions of the highly developed oases and darkened canals were obtained from composite photographs and proportionally enlarged and transferred to a mercator chart shown in Fig. 27. Many of the lower-contrast canal positions were obtained from the high-contrast and high-resolution qualities of improved color film.

Propontis I oasis was the largest and darkest feature of the entire region, with coordinates at 180°, +41° ca. The Propontis I was a junction for six well defined canals. The Hypelaeus Fons was so prominent that at first inspection it was taken for the Propontis I. The Hypelaeus Fons was located at about 169°, +32° ca. and was a terminal for six or possibly seven canal features. The second most prominent feature was the dark gray Euxinus Lacus area measured at 150°, +49° ca.

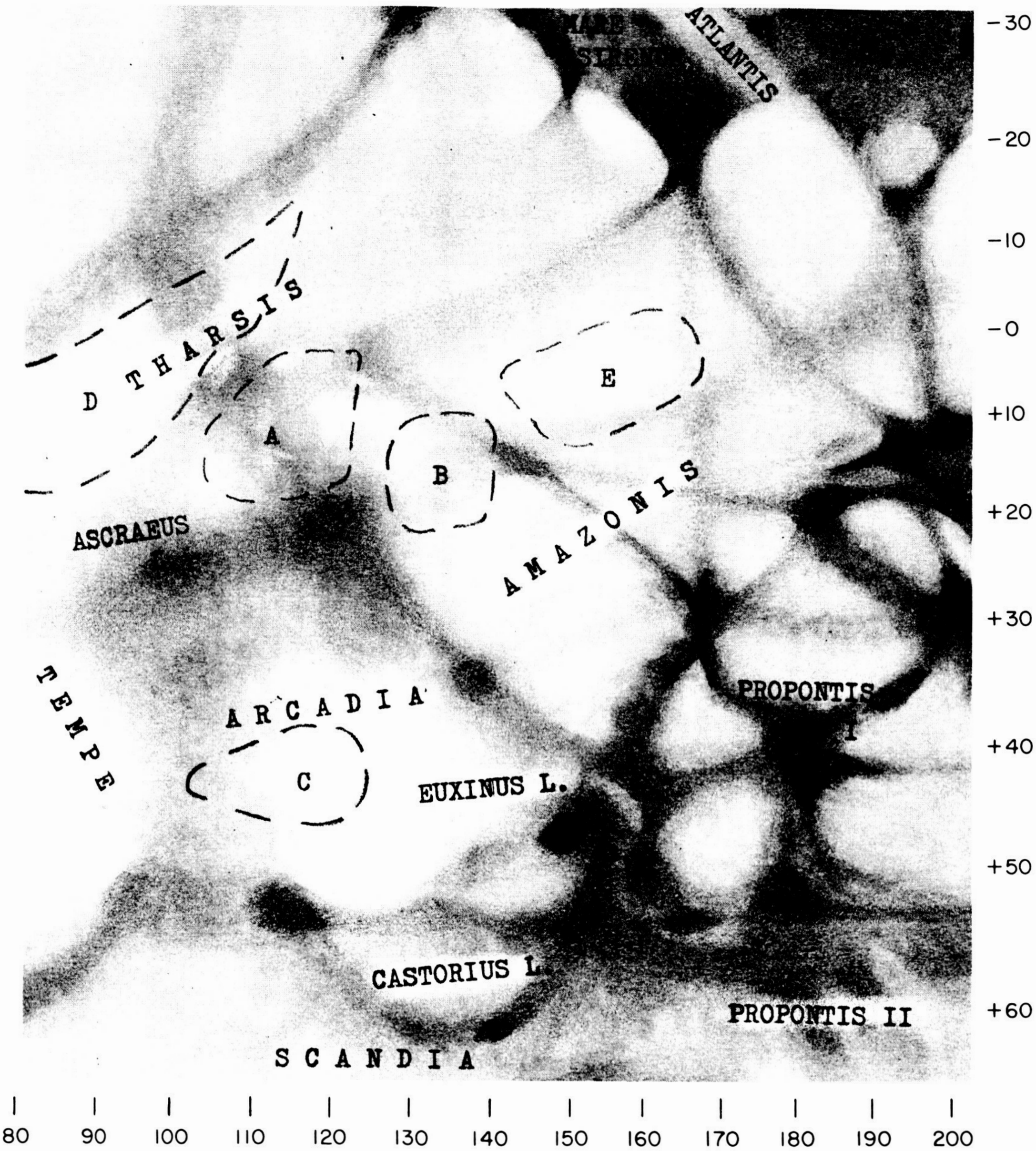



**Fig. 27. The Great Martian Desert region; summer development**

The Castorius Lacus appeared divided into two major east–west sections located at 153°, +54° ca. and 160°, +52° ca., respectively. A dark gray and probably temporary oasis developed at the 159°, +43° areographic position, and was named Ascania Pons by Antoniadi.

The Propontis II oasis was large but with a lower contrast than its neighbors at an approximate position of 178°, +55° ca.

The dark Erebus and Titan II canals formed an obvious photographic lambda pattern with the Hypelaeus oasis. The Erebus canal was broad and dark gray, and it rivaled the Hades canal during the season of maximum darkening. A faint unnamed canal connected the Hypelaeus Fons to the Aernos Fons. The Pyriphlegethon canal was especially bold with a moderate contrast in the Euxinus Lacus area. Many northern unidentified features were registered in the Scandia–Panchaia region shown in Fig. 27.

### D. *Trivium–Cerberus Seasonal Aspect*

The Trivium Charontis is a triangular dark surface feature centered at 198° longitude, +21° latitude

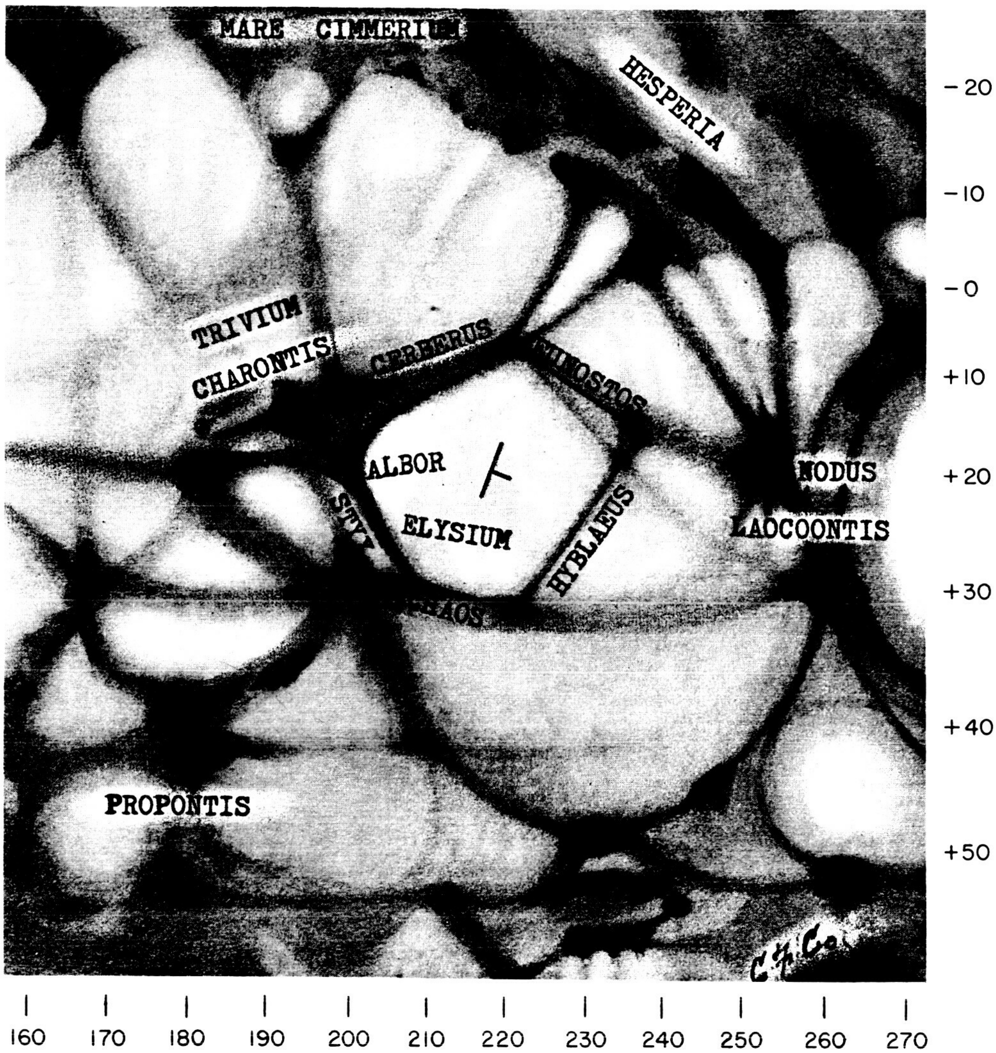



**Fig. 28. Trivium–Cerberus regional map, 160° to 270° longitude; this region of Mars was most active in the optical and radar regions of the electromagnetic spectrum**

(Fig. 28). It is observed to be one of the darkest and best defined medium-size surface areas on the globe of Mars. The Trivium is the junction of a complex system of canals radiating into the ocher-colored barren Amazonis desert, to the dark Propontis complex, and around the adjacent Elysium plateau. The contiguous dark and broad Cerberus I canal is as intimately a part of the Trivium as is the internal oases triad.

The Trivium holds a moderately dark gray contrast throughout winter and early spring. The Cerberus and the Styx canals are weak but can be observed at this season, while the other three peripheral canals to the Elysium are observed poorly or not at all. When the spring darkening wave makes contact with the region, the Trivium takes on an intense black shade, and the Elysium peripheral canals make their appearance one at a time as the seasonal darkening progresses.

During the past 1964–1965 apparition the Trivium started its normal contrast-increase phase in Martian late May, but it never reached its intense black contrast as observed formerly over the past seven apparitions. Throughout Martian June and July it remained a below-normal dark-contrast feature with a definite dark brown hue. The Trivium was observed to have below-average definition. Comparatively, the canal complex was observed to have reached normal seasonal contrast and definition.

The oases triad at the eastern end of the Trivium was inconspicuous until Martian midsummer. A gross dark seasonal development was seen at the far eastern end of the feature.

The Cerberus, Styx, Hades I, Dis, and Erebus canals were primary-contrast features. The Dis and Styx canals formed a double system on the eastern border of the Elysium. The Eunostos I canal became a double canal, with one canal connecting to the Nodus Laocoontis as the Eunostos II canal, and the other one (Eunostos I) terminating at the Thoana Palus. The observed radiating canals are listed as follows: Cerberus I and II, Cyclops, Erebus, Hades, Dis, Tartarus, Laestrygon, and Orcus.

The Trivium longitude was reported to be an area of high radar reflectivity by R. Goldstein (Ref. 14). Since the latitude of this dark feature corresponded closely to the sub-Earth point during the period of radar observation, it is entirely probable that the surface of the Trivium area is relatively smooth and an excellent reflector for the 12.5-cm wavelength utilized.

### E. Elysium Seasonal Activity

During the North Cap's greatest rate-of-change of physical state from that of a solid to a vapor state, a curious, but apparently normal, seasonal event usually manifests itself on the Elysium plateau. The large Elysium plateau is about 1,000 miles or 1,600 kilometers across, or an area of approximately 785,000 square miles. It is located at the coordinates 217° longitude, +22° latitude ca., which is found between the two seasonally active areas of the Trivium Charontis and the Nodus Laocoontis. The Elysium exhibits seasonal and diurnal changes relative to the static contiguous deserts. It is bounded by five canal-like features; and within this pentagon lies the smaller and lighter Albor area, whose frequency of whitening and brightness is normally greater than that of the Elysium itself.

The apparently normal seasonal activity that has been observed by the writer over the past several aphelic oppositions is as follows: Toward the end of Martian May, late-afternoon clouds were observed forming over the Elysium plateau; within a few days, a morning white surface patch was noted on the Albor area in the Elysium. As the Martian season progressed into June, the morning surface whitening expanded to cover the entire Elysium area, but did not encroach upon the adjacent canal system. At sunrise the entire Elysium appeared a brilliant white in the early morning sunlight. As the diurnal rotation of the planetary disk progressed, the brilliancy of the white Elysium started to fade at about 10 o'clock in the Martian morning; by high noon, the whitening was observed to be rapidly decreasing in size (sublimating) toward the Albor area; and when the 2 o'clock afternoon position was reached, the white area had generally disappeared. When the white frost retreats toward the Albor area, it would leave the freshly uncovered surface of the Elysium a dark pink color (Fig. 29). When the Polar Cap reached its greatest rate-of-change in Martian June, there was little noticeable white boundary shrinkage throughout the entire Martian day, the Albor area remained bright white, and there was no apparent regression pink hue present.

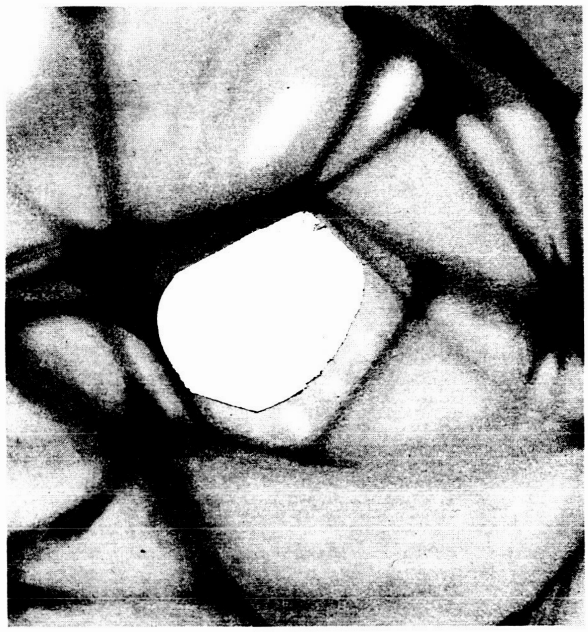
An interesting study of the Elysium region's areographic relief was possible during the 1964–1965 apparition by comparing the deposition and regression of the whitening versus the Martian diurnal time, if the premise is made that the observed white substance is a form of hoarfrost ($H_2O$ or $CO_2$).

In autumn–winter the Elysium was a light ocher hue, and the Albor area within it was a gray-white, in contrast to the normal ocher hue of the contiguous deserts. In late Martian spring the Elysium became completely covered with a sharply defined, brilliant white frost during the cold night, and the peripheral canal system was observed to be at its maximum seasonal darkening. The sharply defined Elysium boundary was further enhanced by contrasting with the dark surrounding canal system.

The Elysium rotated through the subsolar point each Martian day, because the Sun's declination as seen from the center of Mars was +24° during this season. Also, this region appeared at its maximum brightness near noon, because the sub-Earth point was at +21° latitude, which passed through the Elysium.

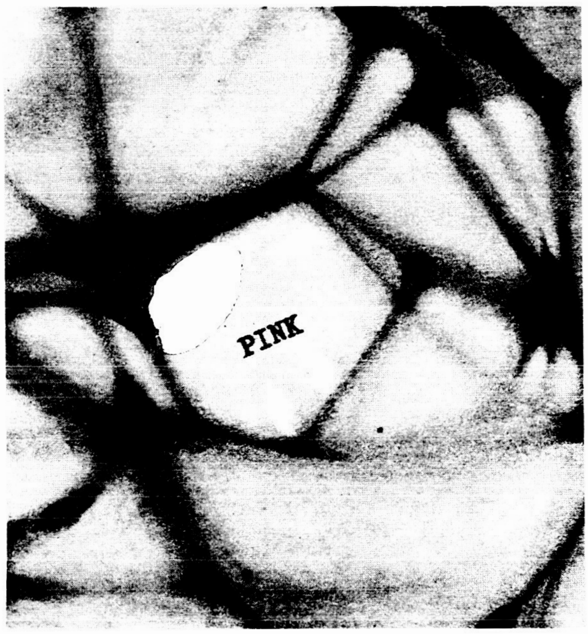
Neither the Trivium nor the canal system has ever been observed to be covered with white frost. This suggests that the Trivium and the peripheral canal system are in some way warmer than the Elysium area. These dark features could be warmer due to differing elevation from the Elysium, or they could be heated by some intrinsic geological mechanism. The adjacent deserts beyond the peripheral canal system do not become white with frost during this season, in contrast to the white Elysium. The Elysium area has been considered an area elevated above the mean level of Mars, such as a plateau, because of the prevalence of the morning whitening and the recurrent evening cloud formation. Dr. R. Goldstein found that the narrow-band echo from the Trivium Charontis ended abruptly when the contiguous area of the Elysium


(a) THE APPEARANCE OF THE ELYSIUM PLATEAU SHORTLY AFTER 9 IN THE MORNING



(b) THE REGRESSION OF THE FROST ON THE ELYSIUM BY 11 IN THE MORNING


(c) THE APPARENT COLOR AND FROST LINE ON THE ELYSIUM AT HIGH NOON




(d) THE REMAINING WHITE FROST ON THE ALBOR AREA OF THE ELYSIUM PLATEAU AFTER 2 IN THE LATE AFTERNOON

**Fig. 29. Elysium plateau diurnal regression of frost and color changes during the Martian late-spring season**

became the target (Ref. 14). The extremely poor radar reflectivity of this area indicates a rough nonreflecting surface.

In Fig. 29 the direction of the diurnal melt regression is shown to move toward the equator at an angle of 20°, from the west toward the east. If the Elysium were level, the diurnal direction of regression should be directly toward the west, because the latitude of the subsolar point nearly equaled the center-of-area latitude of the Elysium during this Martian season. The observed direction of regression is contrary to the planetary physical conditions, which indicates that the Elysium plateau is inclined from the Hyblaeus canal toward the Trivium. The Albor area must be the highest point on the plateau because it retains the white shade throughout the entire day. The line of strike is measured to be about 68° from the parallel, which is normal to the direction of regression. The line of strike approximately coincides with the Hyblaeus canal. The line of strike and direction of dip are shown in Fig. 28.

There are other normally lighter ocher areas in the deserts that are observed to become covered with frost, such as the Hellas plateau, Neith Regio, Nix Tanaica, or the Nymphaeum, which would be interesting to evaluate in areographic relief, given enough quality observations around the time of opposition.

Similarly, the intensely dark surface features are suspected to have elevations below the mean level. This concept is not entirely new; it was formulated by Prof. Lowell and Dr. C. Tombaugh.

### F. *Storm Clouds over the Elysium Plateau?*

Afternoon clouds had been seen forming over the Elysium for several days during Martian mid-June, when an interesting cloud activity was observed during the observing periods of March 30 and 31, 1965 TD (20 June MD). Yellow-green light revealed no sunrise low-level fog-type cloud or haze in the vicinity of the Elysium plateau, and a sharply defined, morning white frost patch covered only part of the plateau. Near Martian noon, violet light indicated small, bright, high-altitude cloud peak concentrations forming in the Elysium region. Blue and blue-green light indicated a less defined round border, and larger medium-level clouds confined to the Elysium area. During this time, yellow-green light showed the surface white patch to be poorly defined and not bright. Integrated light and tricolor filter cross-checking indicated the Elysium white area to be a dull gray-blue. The entire Elysium plateau became bright white and well defined late in the Martian afternoon, while the cloud structure became smaller and better defined. The hourly change in definition, brightness, and size of the Elysium whitening, as well as the apparent atmospheric cloud activity above, observed with the aid of tricolor filters, was remarkable, indeed. The author terms this observed event "storm clouds" over the Elysium.

### G. *Nodus Laocoontis—The Green Knot*

The first record of the Nodus Laocoontis regional development was in an April 13, 1935, drawing by a member of the Oriental Astronomical Association, S. Kibe (Ref. 15). This new marking appeared as a faint dusky surface marking on the eastern edge of the Thoth–Nepenthes canal in the Aetheria desert. This apparently temporary feature was not recorded again until the 1946 apparition, when the OAA once again observed the feature as a faint dark spot connecting the developing Adamas canal with the gracefully curved Thoth canal. The Nodus continued to darken and expand into the ocher desert just southeast of the dark Nodus Alcyonius at 249° longitude, +25° latitude during the next eight years.

Observations made in 1954 by Tombaugh and Capen with the Lowell 24-inch refractor recorded the Laocoontis–Alcyonius region to be extremely large and dark during the Martian late summer and early autumn season. This region had a black-green low-saturated hue, and was composed of four individual nodules (knots) and their respective canal structures. The Eunostos II, Adamas, Aethiops, and Amenthes canals radiated from the swollen Laocoontis. The black-green double Thoth canal curved southwest from the dark Nubis Lacus. The dark gray Casius and Alcyonius canals curved away northward from the Nodus Alcyonius. The faint Nar canal was partially recorded running eastward from the enlarged Thoana Palus. The darkened region was measured to be approximately 23° × 25° or 1,680,000 sq km, which is a gross feature rivaling the champion of maria, the Syrtis Major. The maximum activity of the Laocoontis–Alcyonius region apparently was reached sometime between 1952 and 1954 because the gross darkened region was observed to fade and shrink in size during the following 1958, 1960, and 1963 oppositions.

The Laocoontis–Alcyonius Region was favorably observed during the 1965 opposition. The region appeared quite inactive in late Martian winter with the Nubis Lacus and Thoana Palus missing from the Martian landscape. During the Martian spring, when the darkening wave came up the Casius and Thoth canals, the Laocoontis area became extremely active. The Nodus Alcyonius changed from a dark gray-green into a black-green, the Nubis Lacus germinated into a small black-green oasis, and the Nodus Laocoontis became an intense saturated green feature. The Thoana Palus was not identified as a separate entity during this apparition.

Red spectroscopic plates showed the Laocoontis as an intense dark area, and green plates showed it as a weak low-contrast feature, indicating a color trend toward the green. Visual integrated light and tricolor filter cross-checked observations showed that the Laocoontis area was the greenest feature on the planet. To the integrated eye employing 30 to 80 inches of telescopic aperture, the irregular Laocoontis appeared as a medium-contrast saturated color green area. In red light it appeared black-green, and in orange light it was a bright, spring-green hue.

R. Goldstein received relatively strong radar echos from the Laocoontis 240 to 250° areographic longitudes; and since this area passed through the sub-Earth point, it suggests that the Laocoontis area has a strongly reflecting and relatively smooth surface (Ref. 14).

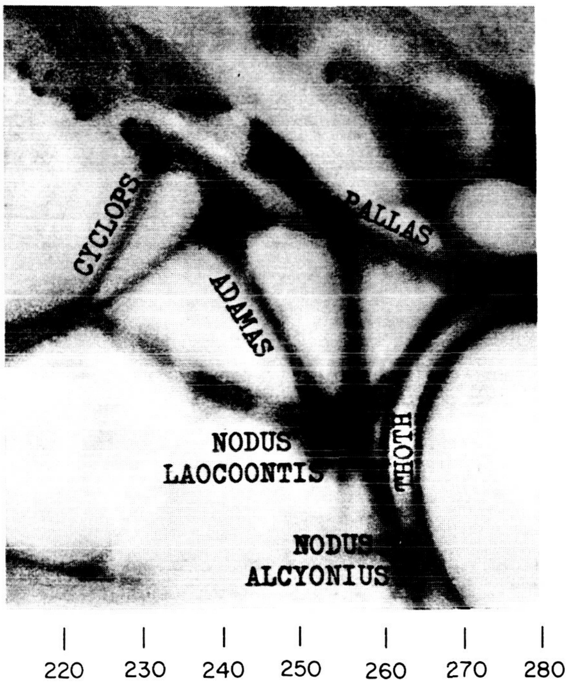



**Fig. 30. Nodus Laocoontis early-spring regional map, drawn from photographs, and showing the gross development on the southern curve of the Thoth–Nepenthes double canal**

Other cohabitants with the Laocoontis feature likewise reflected the seasonal activity (Figs. 30–32). The grand Thoth–Nepenthes canal became a dark gray double canal with gray-blue in-fill. The black-green Moeris Lacus, within the southern section of the Nepenthes canal, developed into two separate oases. The southern section of the Nepenthes canal was well developed in early Martian spring, and in collaboration with the

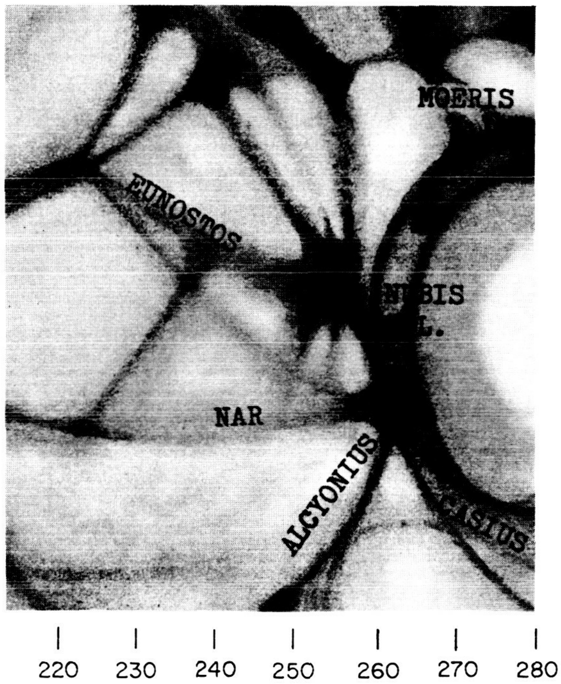



**Fig. 31. Nodus Laocoontis summer regional map, showing the Thoth–Laocoontis–Moeris region; the Nodus Laocoontis was one of the most active areas in the optical and radar regions of the electromagnetic spectrum in 1965**

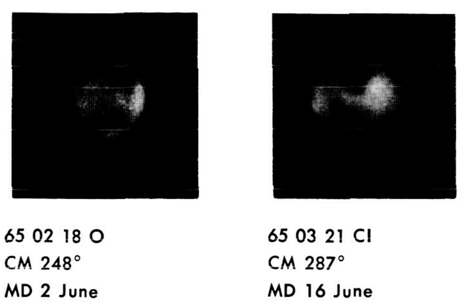



**Fig. 32. Two aspects of the Thoth–Nepenthes canal and Nodus Laocoontis region; the photographs have increased contrast to enhance the central disk features**

swollen Pallas canal, it formed an enlarged, straight feature connecting to the Mare Cimmerium–Tyrrhenum border. All canal structures within this region were well developed by late Martian spring. Later in the spring the Pallas canal was not observed; only the Melos canal remained from the earlier development.

### *H. The Syrtis Major and Environs*

The most prominent and colorful feature on the areographic landscape is without a doubt the grand Syrtis Major. Although this dark surface feature has central coordinates in the northern hemisphere at 290° longitude, +11° latitude, it belongs to the class of southern equatorial dark maria, such as the Margaritifer Sinus, the Aurorae Sinus, and the Meridiani Sinus. The Syrtis Major projects northward from the variegated purple, brown, and gray-blue Mare Iapygia–Tyrrhenum into a light ocher region composed of the Crocea, Libya, Isidis Regio, and the Aeria deserts. These contiguous deserts become seasonally active during the late Martian spring and early summer when they exhibit morning whitening of hoarfrosts or ice-fogs that contrast beautifully with the bright blue-green Syrtis Major. The Aeria desert contains a particularly active white area which is contiguous to the southwest border of the Syrtis, named the Nymphaeum. The Nymphaeum area behaves similarly to the Albor area within the Elysium.

The Syrtis Major was first observed in its northern winter color of dark gray-green during the 1964–1965 apparition. The spring season brought a green-blue color that later changed to a blue-green hue. During the period the North Cap reached its greatest spring rate of regression, the Syrtis was surrounded by early morning blue hazes and hoarfrosts and it became a bright saturated blue color. In Martian summer the color changed to a dark blue-black, particularly at the northern tip, and later it returned to the formerly observed blue-green tint. When last observed during Martian autumn, the Syrtis was once again a green-blue hue. The northern half of the Syrtis usually showed the darkest contrast of the entire feature. The dark gray Dosaran canal, that is sometimes observed traversing the Syrtis longitudinally, was not recorded during this apparition by any of the JPL Mars Patrol observers. According to R. Goldstein's radar observations, the preceding west side of the Syrtis Major, that borders the light Nymphaeum, is a relatively smooth and a radar reflecting area. The circumstance of a dark radar reflecting area contiguous to a well defined light area is similar to that of the Trivium–Albor area.

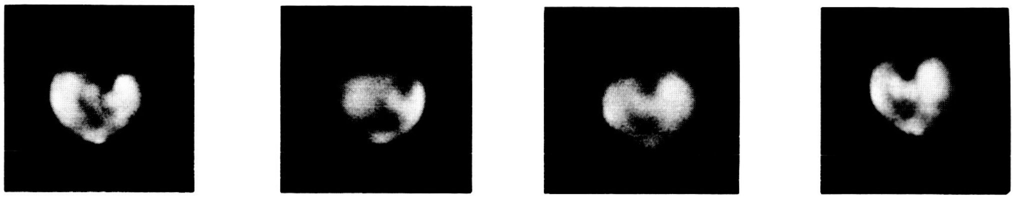
The canal structure leading from the Syrtis Major has undergone secular changes over the past 50 years. The Martian apparitions of 1905–1909 recorded the Thoth–Nepenthes and Nilosyrtis canals as narrow low-contrast features. Professor Lowell and others recorded the Thoth–Nepenthes as a delicate double canal. The Thoth–Nepenthes began to darken and develop from 1916 through 1918. The 1918 apparition recorded the Thoth–Nepenthes and Casius canals as extremely dark, broad, high-contrast features. The Nilosyrtis was likewise broad and dark. The Umbra area was especially well defined at this time. Comparison photographs of the Syrtis region taken at the Lowell Observatory in 1918 and at the Table Mountain Observatory in 1965 are shown in Fig. 33. The Thoth–Nepenthes once again faded during the 1930 apparitions. From 1941 through the 1956 apparitions the Thoth–Nepenthes and Nilosyrtis canals were observed to be increasing in contrast and extent. The height of activity was apparently reached in 1954 when the Thoth–Nepenthes, Moeris Lacus, and the Laocoontis–Alcyonius complex were recorded as large, dark, and colorful surface features. The 1963 and 1965 apparitions showed that the double Thoth–Nepenthes canal is presently declining in contrast. A surface mechanism that can turn a bright ocher desert region into a gross dark region and secularly fluctuate regardless of the Martian season certainly has led to much speculation.

### *I. Martian Seasonal Colors*

The northern and southern dark maria exhibited shade and hue changes throughout the Martian northern hemisphere spring and summer seasons. At the beginning of the observed 1964–1965 apparition, the northern maria were in their late winter colors, and the southern maria were in their late summer or early fall season shades and hues. Regional coloring was visually observed with telescopic apertures from 16-inches to 84-inches during the apparition; however, most weight was given to the 30-inch and 84-inch visual color estimate observations. The following Martian features are presented in the order of increasing longitude:

The Meridiani Sinus was observed to be a dark gray shade in Martian spring and a black shade in the summer season.

The Margaritifer Sinus was first observed with a dark gray and mottled dark brown coloration. It was a dark gray shade and blue-green hue later in the season. During the Martian summer season the Sinus became a black-green hue, and changed to a dark gray and mottled dark brown at the approach of fall.



| A | B | C | D |
|---|---|---|---|
| 18 03 31 Y | 65 02 19 R | 65 03 21 Cl | 65 04 30 R |
| CM 275° | CM 250° | CM 290° | CM 320° |
| MD 25 June | MD 2 June | MD 16 June | MD 5 July |
| Lowell Obs. | TMO. | TMO. | TMO. |

**Fig. 33. Gross dark surface changes in the Syrtis Major region are shown in the above March 31, 1918, Lowell Observatory photograph, compared with three 1965 seasonal aspects of the same region taken at Table Mountain Observatory: in photograph A (MD 25 June), Lowell Observatory, the Moeris Lacus, Nodus Alcyonius, Casius canal, Nilosyrtis canal, and the Umbra are quite broad and dark; in photograph B (MD 2 June), Table Mountain Observatory, the Moeris Lacus shows less dark development in Martian early June, the Thoth canal is well developed and appears as a filled-in single broad canal structure, the Eunostos I and II canals are broad and dark, the Nodus Alcyonius is well developed, and the northern tip of the Syrtis displays low contrast; the Nilosyrtis and Astaboras I canals are not recorded in red light; the Boreosyrtis–Casius Wedge appear as one uniform region; the Pallas and Amenthes canals are well developed; in photograph C (MD 16 June) the Thoth shows weakening of contrast, and a hint of the Nilosyrtis, Astaboras, and Vexillum canals is recorded well on the original negative; the Boresyrtis still appears as a single entity; in photograph D (MD 5 July) much seasonal darkening is in evidence, i.e., the northern tip of the Syrtis is filled in and exhibits extremely dark contrast, the Thoth–Nepenthes canal appears double, the Boreosyrtis region has less contrast and it is breaking up into the Umbra, Copais, and Casius areas; and the Nilosyrtis, Astaboras I, and Astusapes canals are recorded as fine structures**

The Oxia Palus oasis was at first invisible to observation in early Martian spring. During late spring it was seen as light gray, and in summer it became a dark gray feature with good contrast.

The Mare Acidalium changed from its winter shades of variegated grays and brown to a spring coloration of dark gray and blue-gray, with gray-green oases. In late Martian spring and early summer, the Mare was a dark gray shade with a black-green central area and dark gray-green oases. During midsummer, it was observed to be an intense black-green hue; which changed to a dark gray-green the last of summer.

The Baltia and Boreum Maria exhibited identical seasonal changes. This dark region changed from its Martian winter dark gray appearance to a dark gray-blue tint and black shade upon its emergence from beneath the North Cap in spring. These Maria were black-blue throughout the Martian summer season.

The Aurorae Sinus changed from a dark gray to a black shade, and finally to a black-blue hue during the Martian spring and summer seasons.

The Mare Sirenum–Cimmerium was poorly observed because of the northern tilt of the planet. They first appeared as a nondescript medium dark gray in the southern hemisphere summer and fall, and, later in winter, showed a change to a dark brown with blue-gray streaks.

The Lunae Lacus was a medium gray shade in Martian spring and a dark gray-green hue in summer.

The Trivium Charontis was not its usual dark gray and intense black shades. Throughout Martian spring it was a medium to dark brown color. Early in summer it became an olive drab color, probably an addition of green to the brown color. In late summer and early fall it returned to its former moderate brown color.

The Phlegra area was a normal ocher hue during the Martian spring season, that turned to a dark orange color at the approach of summer. It was observed to be covered by white frost patches during the period of maximum regression of the North Cap.

The Elysium plateau was its normal light ocher hue, with the enclosed Albor area being a white-gray shade. The Elysium became dazzling white during the period of rapid regression of the North Cap in late spring and beginning of summer. The diurnal retreat of the white substance left the Elysium a pronounced pink tint.

The Propontis complex began the northern spring season with a medium gray shade, changed to a dark gray and green-black during early summer, lost its green hue in late summer, and remained a dark gray to black shade for the rest of the Martian season.

The most color-saturated area during this apparition was undoubtedly the Nodus Laocoontis. When the darkening wave came up the Casius and Thoth canals, in late Martian spring, the Laocoontis changed from a dark gray-green through a dark green to an intense saturated bright green feature. Green light showed it as a very low-contrast feature; in red light it appeared black, and in orange light it was a bright spring-green hue.

The Nubis Lacus and Nodus Alcyonius, neighbors of the Laocoontis, likewise displayed seasonal color activity by changing from a dark gray-green to a black-green in Martian summer.

The second most colorful feature on the Martian landscape was the Syrtis Major. The Syrtis was first observed in its winter color of dark gray-green. The spring season brought a gray-green-blue hue that changed to a blue-green hue. In early summer the Syrtis became a bright saturated blue color. Approaching midsummer it turned to a dark blue-black, particularly at the northern tip, and later on it returned to the formerly observed blue-green hue. In the Martian autumn season it was once again a green-blue color.

The grand Thoth–Nepenthes canal went through a spring–summer seasonal cycle of: medium gray, dark gray, dark gray-green, black-green, dark gray-blue and gray-green, and finally a dark gray-blue hue.

The entire region composed of the Mare Hadriacum–Ionium, Ausonia Borealis, and the Iapygia Viridis changed from an early southern hemisphere fall color of a weak gray-brown to a yellow-brown in late fall and early southern winter. Where this region was contiguous to the white Hellas area, it was a peculiar pea-green hue.

The Maria Tyrrhenum and Iapygia were a mottled brown color when observed during the first part of the apparition. Later in Martian spring the Maria were observed to be a purple and dark brown color, which remained throughout spring and most of the summer seasons. When last observed in late summer, the Maria were a dark purple hue.

The Utopia–Boreosyrtis region was composed of light and dark shaded areas that exhibited slight hue changes during this apparition. This region first appeared in a dark gray winter shade. As the spring Cap regressed, the region increased in contrast and became a dark gray-blue hue by late Martian spring. In early Martian summer the Utopia–Boreosyrtis took on a green tint, and by midsummer it was an intense blue-black variegated with dark browns, olive drabs, and ocher mottled areas. The general appearance in late summer was a dark blue-gray color.

The Ismenius Lacus was a medium-gray contrast in Martian early spring, a darkening gray in late spring, and a black-green in summer.

The Sabeaus Sinus was first observed in a dark brownish-gray color, that changed to an intense black-blue hue in spring, then into a black-green summer hue, and finally returned to a dark gray shade in the fall season.

The Pandorae Fretum was a dark ocher hue in the Martian southern fall season. It darkened to a medium brown color in winter.

Even though visually and photographically the dark maria appear to be various hues of gray-blue, gray-green, and blue-green, they also contain much ocher coloration within the feature itself. When the area of a dark surface feature is totally isolated from the bright adjacent ocher region of a projected color transparency, the dark feature will appear to have an orangish or ocher tint. This excitation varies according to the degree of color saturation of the dark feature, which appears to be affected by the Martian season. Furthermore, the bright orange deserts contiguous to the dark maria complicate the visual chromatic complementary after-image problem.

# X. DAILY OBSERVATION REPORT OF SURFACE CONDITIONS AND ATMOSPHERIC PHENOMENA

In this section a critical evaluation of all available data for each given night of observation is given. The order follows the syllabus of telescopic observation for easy reference:

1. *Polar regions.* Arctic and antarctic physical phenomena.

2. *Atmosphere.* The appearance of the violet and blue atmospheric disk of Mars and visible cloud formation.

3. *Surface whitenings.* Yellow-green and orange light observations of frost patches and ice-fogs.

4. *Gross dark surface features.* Colorimetry and contrast changes of the maria.

5. *Oases.* The physical appearance of the Lacii and Fons.

6. *Canals.* Usually a listing of observed canals versus the Martian seasonal date.

Data on the spectral range and the color number of the Wratten (W) or Schott (G) filter employed for observation can be found in Sec. III.

**September 11, 1964;** 1248–1311 UT; CM 19°; MD 19 March. The 16-inch Cassegrain telescope employed 315× (power) and a camera. North axial tilt +12°; disk diameter 4″.7; terminator 30° wide.

A large and sharp North Cap extending down to about +60° areographic latitude was observed through a morning limb haze with yellow-green (W-57) and orange (W-23A) filters. The North Cap was not bright and appeared as an off-white or possibly a yellowish hue. A south whitening was vaguely seen through a weak antarctic hood. The south polar hood extended down to about −65° areographic latitude defining a width of about 50°. The north cap peripheral band was clearly seen as a moderate dark, thin band, indicating that the spring melt may have started. A morning limb haze or cloud was observed from +90 to about −10° latitude

(W-47 and W-38). A high-altitude evening-terminator cloud projection was found at 320° to 345° longitude and about −20° to −30° latitude. No atmospheric blue-clearing was detected as the planetary disk appeared completely opaque in violet light (W-47).

In the north, the Mare Acidalium was vaguely seen as a dark gray feature. A hint of the southern maria was noted.

A test film was taken of Mars in yellow-orange and blue light on September 15; 1137–1150 UT, but no useful data were recorded on the planetary disk.

**September 17, 1964;** 1153–1212 UT; CM 308°; MD 22 March. The 16-inch Cassegrain used 500×.

A large and clear North Cap was seen again with a possible yellow tint. A weak south polar hood was detected in blue light (W-38). A weak morning limb haze was noted in blue and blue-green light (W-38 and W-64). The southern hemisphere high-altitude terminator cloud was still easily observed in violet and blue light (W-47 and W-38), and it appeared to have moved northward to approximately −5° or −10° latitude. No atmospheric blue-clearing was detected.

Dark, vague surface features were seen, e.g., the Syrtis Major near the Central Meridian.

**September 19, 1964;** 1226–1238 UT; CM 297°; MD 23 March. The 16-inch Cassegrain operated at 500×; axial tilt +13°8; diameter 4″8 of arc.

The North Cap was bright and white and observed to be free of cloud and haze, with an approximate diameter of 68 or 70 areocentric degrees. The South Cap was not seen. A south polar hood was again noted in blue light (W-38). The morning haze appeared to be weaker, but still held about the same coordinates in latitude from +90° to 0° in blue light (W-38). The terminator cloud had moved down the disk to the equator, and now occupied the Isidis Regio 240 to 285° longitude, −5° to +22° latitude, with its center of area (ca.) at about 258°, +20°. No blue-clearing was noted.

The Maria Tyrrhenum, Syrtis Major, and Umbra were all that were seen of the dark surface features.

**September 26, 1964;** 1233–1322 UT; CM 232°; MD 27 March. The 16-inch reflector used a 500× ocular.

The North Cap was large, clear, and sharp at its edge. A weak antarctic haze was detected in blue light.

No sunrise limb haze was seen; in fact, no general atmospheric haze was seen during this period. The only cloud observed was the terminator cloud located over the Zephyria desert; this cloud appeared the same size and intensity as on the previous night and centered on the equator at coordinates 180° to 210° long.; +20 to −12° lat. A moderate atmospheric blue-clearing confined to the northern hemisphere was detected in deep violet light (W-47 and W-47B) independently by two observers. The Casius–Umbra region and Thoth canal were easily seen in deep violet light.

The Albor area located on the Elysium plateau appeared gray-white, while part of the Elysium was a light ocher to yellow hue.

The southern maria were a weak blue-gray. The Syrtis Major exhibited a dark blue-gray hue to a dark gray shade. The Trivium Charontis was a definite weak brown color. The Umbra region was a dark gray shade. The Thoth–Nepenthes, Alcyonius, Heliconius, Gyndes, Dis, and Hades canals appeared a moderate gray shade. Just a hint of the Nodus Laocoontis was observed.

**September 28, 1964;** 1215–1237 UT; CM 207°; MD 28 March. The 16-inch reflector employed 500×; axial tilt +15°6; diameter 4″9 of arc.

The North Cap was clearly seen free of a cloud hood and haze, and it had a narrow moderate gray periphery at this longitude. A whitening was noted in the antarctic and was seen best in green light indicating low cloud or possibly extensive frost in the Electris–Eridania region.

The atmosphere still seemed to be free of haze. No morning or evening limb haze was detected during this observing period. The terminator cloud was smaller with the position 150° to 180° long.; +10° to −15° lat. It appeared small in yellow-green light (W-57) and became larger in blue light (W-38). A moderate atmospheric blue-clearing was still prevalent in the northern hemisphere. The North Cap dark periphery and Dis–Hades canal complex was observed in deep-violet light (W-47). The blue-clearing appeared weaker this evening than on September 26; however, this may be due to the poor seeing conditions.

Much of the atmospheric visible moisture (clouds and haze) appeared to be freezing out as ground frost or ice-fog. One morning, limb whitening had appeared just south of the equator in yellow (W-15) and yellow-green light (W-57) at the approximate position 280° long.; +15° lat., which placed the white patch on the Isidis Regio. Another white frost area was observed on the evening terminator below the terminator cloud at position 150° long.; −10° lat.

The Trivium Charontis was a weak brown, and the southern maria a moderate blue-green hue. The Dis and Hades canals were vaguely seen connecting to the Trivium oases. Cerberus I was also possibly detected bordering the Zephyria desert.

**September 29, 1964;** 1302–1330 UT; CM 210°; MD 28 March. The 16-inch reflector was aided by a 500× ocular and a camera.

The North Cap was still noted clear and bright with a weak gray periphery. White frost or fog cloud was indicated over the Electris and Eridania light areas, just south of Mare Cimmerium.

Atmospheric haze was on the increase, with a reformation of morning limb haze from about 0° to +60° latitude. A small sunrise cloud was noted in blue-green and blue light (W-64 and W-38) at about 280° long.; −5° lat. The high-altitude evening terminator cloud had increased in size, extending from the terminator line to the Central Meridian: 154° to 210° long.; +20° to −15° lat. A bright, evening, low-type cloud or frost patch was still observed on the terminator at 155° long.; −5° lat. (W-57 and W-64). The atmospheric opacity was increasing in violet light (W-47), allowing only a weak blue-clearing in the northern hemisphere. The Dis and Gyndes canals and the Sithonius Lacus in the Pancharia region were observed in deep violet light.

The moderately dark Trivium was well observed. The Mare Cimmerium appeared to be a blue-gray to blue-green hue.

The Sithonius Lacus and the connecting Gyndes Canal were quite dark and contrasting well with the edge of the North Cap. The Dis canal showed greater contrast than the Hades canal. The dark gray Thoth canal was seen rising on the limb in the early morning haze.

**September 30, 1964;** 1156–1217 UT; CM 183°; MD 29 March. The 16-inch Cassegrain employed 500×; axial tilt +15°.9; diameter 5″ of arc.

The large North Cap was seen shining bright white and clear of clouds and appeared to be of the same size as first observed on September 11. The whitening was still observed at −50° latitude over the Electris and Eridania areas.

The atmosphere once again showed a clearing trend. No limb haze was noted and only one cloud recorded. The terminator cloud had decreased its size measurably; but its center of area (ca.) moved about 10° south, namely −5° latitude, with the coordinates 123° to 138° long.; −20° to 0° lat. The weak blue-clearing still persisted in the northern hemisphere, with the Propontis, Gyndes, and Sithonius Lacus clearly evident in deep violet light (W-47 and W-47B).

A white frost patch or ice-fog was again observed on the evening terminator at 124° long.; −5° lat. A frosted area was also seen in the early morning light at 270° long.; +15° lat.

A very dark band composed of the oasis Propontis II, the Gyndes canal, and the Sithonius Lacus was contiguous to the bright North Cap. The large Propontis complex was clearly seen as a moderate dark gray to dark brown shade. The moderate dark brown Trivium Charontis was better observed this morning, showing no interior oases detail, but exhibiting several connecting canal extensions. The southern maria were also better defined, with the Mare Sirenum and Mare Cimmerium differentiated.

The Dis and Gyndes canals were fairly easy to see, whereas the Hades canal was only a probable observation. The Orcus and Cerberus I and II canals were seen emanating from the Trivium. The usual dark, broad Styx canal had not thus far been identified this season. The long Pyriphlegethon canal or possibly the Brontes canal was recorded crossing the Amazonis desert from the Propontis region in the vicinity of the Euxinus Lacus.

**October 1, 1964;** 1155–1245 UT; CM 175°; MD 29 March. The 16-inch reflector used 315× and 500× oculars and a camera.

The large and bright white North Cap and an extremely clear arctic region were once again observed this night. A possible weak haze was observed over the antarctic region.

The northern atmosphere was still very clear and the same weakening blue-clearing was again observed in the north, with the Propontis, Gyndes canal, and Sithonius Lacus being noted through the deep violet filter W-47B.

A slight equatorial morning haze was recorded. The evening terminator cloud was not noted in the dark phase of the disk, although evidence of it was seen on the evening twilight portion of the disk approximately centered on the equator and over the Amazonis desert.

Only one early morning frost patch was spotted below the equator at approximately 270° long.; +22° lat. (ca.) position on the Isidis Regio desert.

The dark surface features appeared the same as they were observed the preceding night. The longitude of the Central Meridian is that of the "hard-seeing-side" of Mars.

**October 3, 1964;** 1256–1325 UT; CM 170°; MD 30 March. The 16-inch Cassegrain employed 315×, 500×, and 600× oculars and a camera.

A bright and clear North Cap was again observed to be the same size. The weak haze formerly observed in the antarctic was not noted this evening.

The general atmospheric appearance was that of increasing clarity relative to the former observation, with no limb haze noted, and only the weaker evening terminator cloud being observed at the same position over the Amazonis Desert. A moderate blue-clearing was well observed this evening, with the Propontis complex and Sithonius Lacus region appearing prominent in violet light (W-47B).

One small, white frost patch was again observed in the early morning twilight on the Aethiopis–Isidis Regio deserts.

The dark southern maria were well defined. All large, dark surface features appeared the same, with hue and shade as described in the September observation.

**October 4, 1964;** 1246–1314 UT; CM 160°; MD 31 March. The 16-inch reflector used 500×; 32°5 wide terminator.

The shiny, white North Cap was still clear of visual haze and clouds, with a dark, contrasting peripheral knot formed by the Propontis complex. No haze or cloud was seen over the antarctic region.

The atmosphere was still quite clear, although the evening terminator cloud was observed to have increased in size covering 115° to 125° long.; +25° to −15° lat. in the Tharsis–Amazonis desert region. No morning or evening limb haze was detected. The northern hemisphere blue-clearing was noted to be weaker and fading relative to the former night's observation; however, the Propontis complex and Gyndes canal were easily observed in deep violet light (W-47B).

An early morning frost patch was seen on the Aethiopis–Elysium region.

The dark gray southern maria and the dark Propontis complex were noted on the Martian disk; however, the "hard-seeing-side" disclosed nothing on the large ocher tracts of the Arcadia and Amazonis deserts.

**October 5, 1964;** 1227–1231 UT; CM 142°; MD 31 March. The 16-inch reflector employed a 500× ocular.

The large, bright North Cap was observed to be still clear of visible moisture and of the same measurable size. No antarctic haze was detected.

The Martian atmosphere was becoming increasingly opaque to violet and deep-blue light with an increasing terminator cloud and high-altitude haze; consequently, only a weak blue-clearing was detectable in the extreme, clear arctic region.

Only the dark gray southern maria and the dark Propontis oases complex at the north cap periphery were observed on the Martian disk.

**October 6, 1964;** 1225–1240 UT; CM 132°; MD 31 March. The 16-inch reflector employed a 500× ocular.

The North Cap was of the same apparent size and clear of arctic haze. No antarctic haze was noted.

The Martian atmosphere was still increasing in visible moisture with an extensive northern hemisphere morning haze extending from +45°, −10° lat.; an increasing terminator cloud covering the Candor–Tharsis desert region at 75° to 105° long.; +15° to −10° lat.; and an extensive evening high-altitude haze covering approximately 75° to 125° long.; +40° to −30° lat. The Martian atmosphere was showing an increasing opacity to violet and deep-blue light; consequently the blue-clearing was fading and it was confined to the still-clear arctic region from about +50° to +90° latitude. The Propontis complex was weakly seen in deep violet light.

An apparent early morning frost storm was observed over either the Elysium plateau or the Zephyria desert.

Blue light indicated a fuzzy cloud concentration surrounding a sharply defined yellow-green-light frost or low-type fog cloud.

Only the dark Propontis oases complex and Hades–Dis canals were observed on the surface.

**October 7, 1964;** 1228–1243 UT; CM 123°; MD 1 April. The 16-inch Cassegrain telescope was employed using 500×.

The North Cap was observed to be static in size and clear of clouds and haze. An antarctic haze or weak polar hood was detected this night in blue (W-38) and violet (W-47) light.

The Martian atmosphere was generally cloudy and hazy, except for the extreme northern hemisphere. An extensive evening terminator cloud was seen extending to the disk center, which covered the Tempe, Candor, and Tharsis deserts, and was observed best in violet W-47 light. A morning limb haze was again observed in blue and violet light from about +50° to 0° latitude, with a blue cloud concentration over the Zephyria frost area. Only a weak blue-clearing was observed in the extreme north.

The same morning frost, or snow area, was again observed on the Zephyria desert in orange (W-106) and yellow-green (W-57) light.

The dark gray Propontis oases and Mare Boreum were observed in the north; they formed the darkening peripheral band of the North Cap. Nothing was observed in the south or central regions on the disk.

**October 9, 1964;** 1247–1257 UT; CM 108°; MD 2 April. The 16-inch Cassegrain employed 666×.

The North Cap appeared to be a dull, gray-white with a rather diffuse, broadening medium gray peripheral band. The antarctic region was still covered by an extensive polar hood which extended northward along the evening terminator down to about −30° or −35° areographic latitude.

No atmospheric blue-clearing was detected in violet or blue light during this observation. Apparently, the long blue-clearing period that was first detected on September 26 had come to an end on October 8, having lasted 12 days. An intense morning haze was easily seen extending from the arctic region to about the equator, 0° latitude, where a bright patch was seen in yellow-green (W-57) and blue-green (W-64) light, indicating a near-surface feature at 175° to 200° longitude over the Zephyria–Mesogaea desert.

The Mare Acidalium was vaguely seen in the light of evening, and the Mare Boreum was observed in the far north. The connecting Ceraunius canal was vaguely seen crossing the Central Meridian (CM).

**October 11, 1964;** 1254–1315 UT; CM 89°; MD 3 April. The 16-inch Cassegrain with a 500× ocular.

The clear North Cap and its broadening peripheral dark band appeared much the same as on October 9. The antarctic hood had increased in size. Nothing was seen of the South Cap.

The atmosphere increased in haze, cloud, and opacity. No atmospheric blue-clearing was detected in violet light. The evening terminator haze had increased down to below the equator to about +25° areographic latitude. No morning limb haze was found.

The same surface white patch that had been observed each morning since September 28 was still noted on the equator at 160° to 180° longitude, lying on the Zephyria–Mesogaea desert.

The moderately dark Maria Acidalium and Boreum were all that were observed on the surface disk of Mars.

**October 12, 1964;** 1236–1300 UT; CM 77°; MD 3 April. 16-inch Cassegrain with a 500× ocular, +18° axial tilt, 5″.2 disk diameter. The terminator was 33° wide.

The North Cap was slightly brighter than at the last observation; it was clear of clouds and haze, and was pure white. The moderately dark peripheral band was wider than formerly noted, but not any darker or with more contrast. The antarctic polar hood was still large and dense, and no South Cap formation was observed beneath it.

No atmospheric blue-clearing was detected. The evening terminator haze was still more extensive than before, extending down to about +30° areographic latitude, just above the Mare Acidalium covering the Chryse desert, and about 20 areocentric degrees at its greatest visible breadth.

Just a thin white patch was observed in orange and green light on the morning limb equator. Has the frost patch reached its limits in longitudinal motion and is it confined to the Mesogaea–Zephyria desert region? A second white patch revealed itself under the evening terminator haze on the Chryse desert at the position 25° to 35° long.; +10° to +22° lat.

The Acidalium and Boreum were the only maria noted, and they appeared a nondescript gray. No canal-like features were observed in the north at this season.

**October 13, 1964**; 1240–1315 UT; CM 67°; MD 4 April. 16-inch reflector employed 666× and 320×.

The North Cap was clear of clouds, appeared a pure bright-white shade, and seemed the same physical size. The North Cap periphery was moderately dark and still expanding in width. The antarctic hood was smaller, but still no surface whitening was seen beneath it.

No atmospheric blue-clearing was seen in violet or blue light. Visible atmospheric moisture was much less this morning than on October 12. Only a smaller south polar hood extended northward into an early morning haze to about −10° areographic latitude was observed.

The same morning frost patch or ice-fog was observed once again on the Mesogaea desert.

The Maria Acidalium and the long, narrow Boreum were vaguely observed. The Tempe, Arcadia, and Amazonis deserts appeared quite blank.

**October 14, 1964**; 1103–1107 UT; CM 33°; MD 4 April. 16-inch Cassegrain telescope used 500×.

The North Cap appeared the same as it did on the former morning observation. Due to poor observing conditions it was not possible to observe the south polar hood.

No clouds were observed on the Martian disk, probably because of the poor sky transparency. No blue-clearing was detected.

An early-morning frost patch was observed again at the same areographic latitudes from 0° to −10° on the Tharsis desert just underneath the Martian Eye of the Thaumasia–Solis Lacus–Coprates region at 110° areographic longitude (ca.).

Only the large and moderately dark gray Mare Acidalium was recorded before the observation was terminated by terrestrial clouds.

**October 16, 1964**; 1300–1330 UT; CM 43°; MD 5 April. 16-inch Cassegrain telescope employed a 500× ocular and a camera.

The North Cap was seen as a bright, white, hazy arc surrounded by the moderately dark gray Maria of the Boreum and the northernmost part of the Acidalium. The physical size of the Cap appeared slightly smaller than first observed; it now had a 65° diameter. The south polar haze hood was still clearly seen with an approximate diameter of 57°.

No atmospheric cloud was recorded. A possible weak morning limb haze was noted. Only the south polar hood stood out as visible moisture. No atmospheric blue-clearing observation was made.

The same white frost patch was observed below the Martian Eye at 110° long., −5° lat. (ca.).

The Maria Acidalium and Boreum were sharply observed to be a nondescript dark gray. A first good look at the southern maria was accomplished this morning. The Sabaeus Sinus appeared dark gray with a definite forked Meridiani Sinus at its tip. The graceful Margaritifer Sinus was clearly seen connecting to the relatively dark Pandorae Fretum. The Deucalionis–Aram Regio, separating the Sabaeus from the Pandorae and Margaritifer, appeared light ocher and normal for the season. The Aurorae was a normal autumnal season dark blue-gray. Farther toward the south, the dark Mare Erythraeum seemed too light in contrast and hazy. The Noachis appeared a normally light ocher color. The light areas of Argyre I and Ogygis Regio were nondescript, being slanted away from view in the south and juxtaposition to the antarctic hood. The Bosporus Gemmatus was observed bordering the Solis Lacus.

The Acadinius Fons showed a darker contrast than the surrounding Mare Acidalium. The Acidalius Fons was quite dark in the Mare Boreum and contiguous to the North Cap, which indicated that the cap edge limit was at the +57 or +58° parallel. The Siloe Fons was also noted.

The Ceraunius, Phryxus–Nilokeras I, Oxus, and Agathodaemon canals were in evidence on the telescopic disk.

**October 18, 1964**; 1205–1215 UT; CM 11°; MD 6 April. 16-inch Cassegrain employed 666×.

The North Cap was a dull-gray and was ill-defined as if it was covered by haze. Blue light observation showed a larger Cap than in red light. The south polar hood was still evident.

No atmospheric blue-clearing was detected in violet light on the Martian disk. A morning haze was recorded from the North Pole to about $-10°$ latitude. No terminator clouds were in evidence.

A large, bright frost patch was on the Candor–Tharsis desert region below the Martian Eye of the Solis Lacus and contiguous to the Coprates complex.

The Mare Acidalium was well defined in red-orange light, and was a nondescript dark gray in the 16-inch aperture instrument. The southern maria appeared in the same physical aspect as on the morning of October 16.

The Phryxus–Nilokeras I canals were noted in the north extending from the Acidalium. The Oxus and the Agathodaemon canals were seen in the south, and possibly the short Aurorae canal was seen joining the Margaritifer to the Aurorae Sinus.

**October 20, 1964;** 1217–1228 UT; CM 354°; MD 7 April. 16-inch reflecting telescope was employed using 500×. The disk phase was noticeably increasing.

The North Cap was rather dull gray-white and was not sharp on the edge, indicating possible erratic arctic haze or ice fog over the moderately dark peripheral band. The south polar hood had increased in physical size since the last observation of it on October 18, and it appeared as large as the North Cap.

No atmospheric blue-clearing was detected in violet or blue light. Morning limb haze was seen to extend from the North Pole and across the equator to about $-10°$ areographic latitude.

A large, bright frost patch or ice-fog was observed again on the equator in the Candor–Tharsis desert region below the Martian Eye.

The southern maria were not well defined in the poor astronomical seeing. The Mare Acidalium appeared the same as observed formerly.

**October 21, 1964;** 1300–1332 UT; CM 355°; MD 7–8 April. 16-inch Cassegrain with 500×; $+19°$ axial tilt.

The North Cap was more clearly seen than it had been observed since October 18, but a morning haze still persisted over part of the Cap and its periphery. The north cap peripheral melt-band or fringe was quite dark and much broader in the most northern part of the Mare Acidalium. The south polar whitening was measurably smaller and it appeared more sharply defined in yellow-green and blue-green light than in violet, blue, or red light, indicating a low haze or fog-type cloud covering a much smaller area of the antarctic. Could this antarctic whitening lie on the surface?

A morning limb haze extended from the North Pole to about the equator. A blue-gray haze or medium cloud was seen on the evening terminator extending from about the equator to the antarctic whitening. Violet light showed a brighter, more uniform disk than blue light.

The Mare Acidalium was easily seen in the north, while the southern maria were poorly observed. The dark Sabaeus Sinus was the only outstanding surface feature in the south.

No canal-like features were seen on the Martian disk.

**October 25, 1964;** 1330–1340 UT; CM 323°; MD 10 April. The 16-inch reflector used 500×.

The arctic region possibly had some local area ice-fogs. The North Cap looked fairly bright and sharp. The north cap peripheral band was broader and displayed a greater dark gray and brown contrast. The antarctic region was covered by a polar haze hood as noted in blue light (W-38). A bright frost area was seen on or near the surface through the south polar hood in integrated, orange, and yellow-green light, but was not seen in blue or violet light. This bright frost area was at an approximate position of 298° to 320° long.; $-35°$ to $-50°$ lat., which locates the bright area on the Hellas plateau.

A morning limb medium-altitude cloud was seen best in blue-green light (W-64). An early morning haze extended from the equator into the arctic region. An evening terminator blue-gray haze extended from the antarctic polar hood $-90°$ to $+20°$ lat. No blue-clearing was noted in violet light.

Low fog or frost was indicated in yellow-green light on the morning limb from the equator to the antarctic polar hood.

The dark gray-green shadow of the Syrtis Major was seen just past the Central Meridian of the disk. The

Wedge-of-Casius and the Umbra–Copais Pons were paramount dark gray features on the northern half of the planetary disk. The southern Maria Tyrrhenum and Sabaeus Sinus were vaguely seen.

The broad, moderate gray contrast Thoth–Nepenthes canal was observed as a singular feature sweeping across the ocher deserts. The Protonilus and Pierius were poorly seen in the Dioscuria desert because of their weak seasonal contrast.

**November 4, 1964;** 1222–1255 UT; CM 209°; MD 14 April. A 16-inch Cassegrain telescope was employed using 500×; +20°6 axial tilt. Terminator 35° wide. Disk diameter 5″.8.

The North Cap had become measurably smaller in physical size with a diameter of 63° to 64°; and encompassed by a wide, dark peripheral band. The arctic region was clear of haze and cloud. The south polar hood was about 62° in diameter in violet and blue light, and it appeared very tenuous to yellow-green and blue-green light. A smaller antarctic whitening was detected through the south polar hood in yellow (W-12) and yellow-green light (W-57), probably frost re-forming the South Cap.

No atmospheric blue-clearing was detected in violet light. No clouds were evident on the Martian blue disk.

A dazzling early-morning frost region was easily seen on the haze-free limb extending across the Wedge-of-Casius, from the north polar cap periphery +58° lat. to +30° lat. This large and heavily frosted region covered the Neith Regio, and was of brightness equal to that of the North Cap.

The Utopia Region was a gray-green, becoming a darker gray-green farther toward the south in the Wedge-of-Casius area. The Trivium Charontis appeared weakly even on the Central Meridian. The Syrtis Major had a dark, gray-green hue in the light of early morning. The Maria Cimmerium and Tyrrhenum were vague, and no coloration was detected.

The Propontis region appeared a medium contrast with a gray-blue hue in the evening twilight. The Laocoontis–Nubis–Thoana–Alcyonius Nodus complex had not been sighted thus far during this apparition.

The Phlegra region appeared light ocher. The Elysium plateau with its bordering canal system was not evident.

The broad Thoth–Nepenthes canal was observed to be a medium contrast shade of gray and singular in structure. The Alcyonius, Heliconius, and Casius canals were easily seen and appeared to be of a gray-green color. The Hades, Dis, Bidis, and Styx canals were difficult to see.

**November 21, 1964;** 1226–1256 UT; CM 48°; MD 22 April. The 16-inch Cassegrain telescope employed a 500× ocular and a camera. +22° axial tilt. Terminator 37° wide. Disk diameter 6″.4.

The Martian arctic was possibly covered by a blue light haze, although the Cap appeared sharp in orange light. The North Cap showed no measurable change in physical size. A weak antarctic haze was seen in blue light.

No atmospheric blue-clearing was detected in violet light. A possible morning limb haze centered on the equator was present.

No apparent changes were exhibited in the Mare Acidalium relative to the observation of October 21.

The Nilokeras I canal was recorded.

**November 23, 1964;** 1341–1405 UT; CM 48°; MD 23 April. The 16-inch reflector used an eyepiece giving 250×.

The North Cap appeared white and of the same physical size. The weak antarctic blue haze still persisted, and its center of area was not over the South Pole.

Regardless of poor astronomical seeing, much cloud and haze activity was observed in the Martian atmosphere. A sunrise limb haze was detected in blue light, and a possible evening terminator cloud was noted in blue light south of the equator. The seeing was too poor to determine the violet opacity of the Martian atmosphere for blue-clearing.

A bright frost patch was seen on the morning limb equator on the Candor–Tharsis desert below the Martian Eye.

The gross dark surface features were vague.

**November 24, 1964;** 1258–1309 UT; CM 27°; MD 24 April. The 16-inch Cassegrain used a 320× eyepiece.

No change was noted in the Martian disk from the former observation on November 23 under similar poor astronomical seeing conditions.

No atmospheric blue-clearing was detected in violet light. The atmospheric cloud and haze activity was of equal intensity to the former record.

**November 25, 1964;** 1200–1206 UT; CM 2°; MD 24 April. The 16-inch reflecting telescope employed a camera.

The sky conditions were rather poor, indeed. However, the North Cap appeared clear, white, and large, retaining about the same apparent physical size as it had on November 4. The north cap peripheral band was moderately dark brown, broad, and well defined, indicating that Cap melting was taking place.

The morning limb appeared bright in the vicinity of the equator, indicating the presence of a possible morning haze. No cloud or haze was seen on the equator.

The Maria Acidalium and Boreum were vaguely recorded before the observing period was clouded out.

**December 6, 1964;** 1210–1323 UT; CM 260°; MD 29 April. 16-inch Cassegrain employed 500× and cameras, and a 6-inch refractor using 280×. 22° axial tilt. Terminator 37° wide. 7″ disk diameter.

The North Polar Cap was clear of clouds, bright white, and measurably smaller. The North Cap edge was at approximately the 61° or 60° parallel, giving the cap a width of 60°. The north cap peripheral dark gray band was developing well in the Utopia region. A weak antarctic polar hood was recorded in blue light.

No atmospheric clouds were found on the evening terminator or on the morning limb. A morning limb haze was recorded extending from about 0° to +40° lat. A general weak blue-clearing was detected in violet light (W-47B). The atmosphere was not totally opaque to violet light.

The majestic Syrtis Major appeared a gray-blue color. The Utopia–Umbra region was a dark gray shade.

The curving gray Thoth was observed as a single feature.

**December 7, 1964;** 1225–1247 UT; CM 255°; MD 30 April. The 16-inch Cassegrain used 500×.

The clear North Polar Cap was bright and white. The north peripheral band was fairly broad and a dark gray shade. A weak south polar hood was seen in blue light.

The same general atmospheric blue-clearing was noted again in violet light. A weak morning limb haze was seen from 0° to +40° latitude. The Martian atmosphere appeared generally clear of cloud activity during this observational period.

The Syrtis Major still appeared a gray-blue hue. The graceful Thoth canal was a moderate dark gray shade.

**December 10, 1964;** 1330–1416 UT; CM 245°; MD 1 May. The 16-inch Cassegrain employed a 500× ocular.

The North Polar Cap appeared sharp on the edge, clear of haze and cloud, and was a bright white shade. The broad north peripheral band was sharp and dark. The antarctic hood was larger than observed on the former night.

The return of visible atmospheric moisture was apparent on the Martian disk in blue light. The morning limb fog still persisted from about −5° to +35° latitude. A high-altitude sunrise cloud was noted on the equator in violet (W-47) and blue (W-38A) light. A large, high-altitude, evening terminator cloud was evident in violet light. A very weak blue-clearing was still evident.

The dark surface features exhibited little apparent change during this Martian season.

**December 14, 1964;** 1255–1358 UT; CM 200°; MD 3 May. The 16-inch reflector used 500×.

The North Cap was free of cloud and haze, and its peripheral dark band was broad and well defined. No antarctic surface frost or snow was seen through the large polar hood.

Much visible moisture activity was noted in the Martian atmosphere during this observational period. No atmospheric blue-clearing was detected in violet (W-47 and W-47B) light. A large, round, blue evening terminator cloud was centered on the equator in violet light, and expanding toward the north in blue light. A northern hemisphere limb haze was seen best in blue-green (W-64) light and not so well in yellow-green light (W-57). This limb haze extended from +20° latitude to the North Cap edge.

A morning-limb white frost area was seen bright and sharp in yellow-green light, less sharp in blue-green light, and not noted in blue light. This morning frost was at position 265° to 285° long.; +30° to +10° lat. on the Isidis Regio desert.

The gray Thoth canal was well observed in yellow and orange light. The Trivium–Elysium region was difficult to observe, and apparently of low contrast this season.

**December 15, 1964;** 1254–1415 UT; CM 190°; MD 3 May. The 16-inch Cassegrain used a 500× ocular and a camera.

The North Polar Cap was clear and white, with a moderately dark, narrowing peripheral band. The antarctic hood was much fainter, and appeared to be fading away.

No atmospheric blue-clearing was noted. The same morning limb haze extended from +20° latitude to the edge of the North Cap. Two evening terminator clouds were observed in violet and blue light. One of the terminator clouds was centered generally on the equator over the Amazonis desert, and it extended lower in altitude depth of the two, being observed well in violet, blue, and blue-green light. The other terminator cloud was larger and apparently higher, and it was located over the northern Amazonis desert and the Propontis region.

The same morning white frost patch was observed on the Isidis Regio.

Utopia appeared a dark gray in the north. The southern maria exhibited better contrast during this observation. The Trivium Charontis and its related canal system were very nondescript and of low contrast.

The Dis, Gyndes, and Alcyonius canals were noted.

**December 17, 1964;** 1315–1425 UT; CM 175°; MD 4 May. The 16-inch Cassegrain employed a 500× ocular and a camera.

The North Cap was clear, sharp, and white. The antarctic polar hood continued to fade. Some clear frost was seen on the lighter ocher regions in the antarctic.

No blue-clearing was detected this morning. The same early morning fog and two terminator clouds appeared much weaker and seemed to be fading.

A small morning frost patch was observed either on the Aethiopis or the Isidis Regio.

The same gross dark surface features were observed unchanged. Weak desert dark markings were noted on the "hard-seeing" longitudes of Mars—in the Arcadia–Amazonis desert region.

**December 22, 1964;** 1116–1141 UT; CM 95°; MD 6 May. The 16-inch Cassegrain used 500× and a camera.

The North Cap was clear of haze and bright white. The south polar hood had dissipated. Nothing was seen of any surface whitening in the antarctic.

The visible moisture activity continued to decrease in the Martian atmosphere. No blue-clearing was detected in violet light. No morning limb haze was seen. One small, bright blue evening terminator cloud was observed in violet and blue light just north of the equator over the Chryse–Candor desert located at 40° to 60° long., 0° to +20° lat.

No frosted areas were recorded.

The dark and broad Mare Boreum was well recorded as the north cap dark peripheral band. No detail was seen in the Arcadia–Amazonis desert.

**December 29, 1964;** 1109–1147 UT; CM 27°; MD 10 May. The 16-inch reflector employed a 500× eyepiece and a camera.

The white North Cap was seen large and clear, surrounded by a moderately dark and broad peripheral band. The antarctic was free of haze and clouds.

The opacity of the Martian atmosphere to violet light was very low in the northern hemisphere; and the Maria Acidalium and Boreum were recorded in blue and violet light, defining a blue-clearing. No atmospheric clouds were seen. No morning limb haze or fog was recorded.

An equatorial frost patch was observed north of the equator on the Candor desert just below the Martian Eye.

The Maria Acidalium and Boreum were easily recorded in orange and green light, and were less sharp in blue and violet light.

The Nilokeras I and II canals were visible in the Tempe desert.

**December 30, 1964;** 1246–1321 UT; CM 41°; MD 10 May. The 16-inch Cassegrain used 500× and a camera.

The North Cap was still bright and clear of cloud with a well defined periphery. No south polar hood was present in the antarctic.

No clouds or haze were observed in the atmosphere of Mars. A medium intensity blue-clearing was observed visually and recorded photographically in violet and blue light.

There was some green-light evidence for the existence of a morning limb ice-fog or frost over the $-10°$ to $+40°$ latitude.

The Maria Acidalium and Boreum were equally well observed in orange light as in blue and violet light.

The Nilokeras I and II canals were observed in blue and orange light.

**January 1, 1965**; 1152–1331 UT; CM 8°–30°; MD 11 May. The 16-inch Cassegrain used 500× and a camera.

The North Cap was approximately the same large physical size, and appeared bright and clear of cloud or haze. No trace of the south polar hood was found in blue light.

The Martian atmosphere appeared extremely clear and free of cloud and haze. The Martian northern atmosphere exhibited a medium transparency to violet light, once again defining the existence of a blue-clearing in the northern hemisphere.

Frost or early morning ice-fog was again noted on the sunrise limb.

The Maria Acidalium and Boreum were well observed in all color filters; i.e., orange, yellow, yellow-green, green, blue, and violet.

**January 2, 1965**; 1047–1148 UT; CM 350°; MD 11 May. The 16-inch Cassegrain used 500× and 666× and a camera.

The North Polar Cap was still clear of cloud and bright and sharp. The antarctic appeared cloud-free.

The Martian atmosphere was clear of cloud and haze. A weak blue-clearing was detected in violet light confined to the northern hemisphere.

An early morning frost or ice-fog was still noted on the following limb.

The northern and southern maria appeared a dark gray.

**January 9, 1965**; 1110–1246 UT; CM 300°; MD 15 May. The 16-inch Cassegrain employed 500× and cameras. Axial tilt $+22°$.

The North Cap was seen bright and sharp in orange and green light, but showed a weak blue haze in blue light. The North Cap physical appearance was measurably smaller with the edge at approximately $+65°$ areographic latitude, defining a breadth of about 50°. The north cap peripheral band had less contrast, and therefore was only a moderately dark shade of gray. The antarctic region showed no haze or frost whitening.

The south and central parts of the Mars disk were opaque to violet and blue light. A general increase in atmospheric haze was suspected. A possible, but unconfirmed, very weak blue-clearing was suspected in the extreme north around the north cap periphery. This blue-clearing may have been only an observed contrast effect between the bright North Cap and the dark Utopia–Copais region in violet light. A long, fine, dark streak was recorded in blue light in the southern hemisphere extending from the evening terminator at coordinates 246° long., $-30°$ lat. and slanting across the opaque blue disk in an atmospheric juxtaposition with the Mare Tyrrhenum to the morning limb at coordinates 30° long., $-10°$ lat. No atmospheric cloud concentrations were noted in violet or blue light.

Early morning frosting was seen on the equator on the following limb. The Hellas plateau, just south of the Syrtis was bright white, but not as bright as the North Cap in the opposite hemisphere.

The Syrtis Major, champion of Martian markings, was recorded as a dark gray shade just past the Central Meridian. The north tip of the Syrtis surrounding Nili Lacus was a blue-green hue. The Wedge-of-Casius and Utopia region was a very dark gray. The Sabaeus Sinus was a dark gray contrasting with the light ocher hue of the Deucalionis Regio. The Mare Tyrrhenum appeared in dark and light brown tints.

The Antigones Fons and the Ismenius Lacus complex were observed to be of an excellent dark gray contrast.

The Casius, Astaboras I, Nilosyrtis, Protonilus, and Deuteronilus canal-like surface features were recorded.

Quality multicolor and color film photographs were obtained this period.

**January 10, 1965;** 1230–1424 UT; CM 300°; MD 15 May. The 16-inch reflector with 500× and a camera. Disk diameter 9″.

The North Cap was clear and sharp and visually growing smaller. A haze was noted over the antarctic region in blue-green and blue light.

A return of the Martian atmospheric haze and clouds was evident on the limb and terminator. The opacity of the atmosphere to violet and blue light had increased. Evening terminator and morning limb haze were recorded from the equator to the antarctic region. A very weak blue-clearing was again suspected in violet light. The formerly observed atmospheric narrow, dark streak was again recorded in blue light, with its following limb end shifted slightly northward by about 10 or 15 degrees. The dark atmospheric streak's position was approximately 250° long., −30° lat. on the terminator, to 30° long., 0° lat., on the morning limb. Confirmation of the unusual phenomenon has been made from the facts that it was recorded in blue light on two different nights and that it showed both times on composite images. During this observing period, there appeared to be a planet-wide light band noted in blue-green and in yellow-green light running parallel to the equator with the approximate positions: 270° long., +30° lat., to 30° long., +10° lat. Does this green band represent a true yellow dust cloud or is it visible moisture?

The Noachis region appeared very light as if partially covered by frost. The Hellas plateau was hazy and white in yellow-green light.

The Syrtis Major displayed its usual bold character and showed the same hue and shade as recorded during the former observation. The Sabaeus Sinus, Utopia, and Umbra regions appeared the same dark gray shade.

The Ismenius Lacus was a dark gray and well defined.

The Protonilus was the only canal observed this period. Could the lack of canals be due to the above observed green light band which lies just to the south of the Protonilus canal?

**January 11, 1965;** 1200–1339 UT; CM 290°; MD 15–16 May. The 16-inch Cassegrain telescope employed a 500× ocular and a camera. The 6-inch refractor used 280×. 33° terminator width. Disk diameter 9″ of arc.

The North Cap was observed to be white and free of cloud and haze. The Pierius–Callirrhoe canal formed a narrow, dark peripheral band. The antarctic was likewise observed to be clear of haze and cloud.

The opacity of the Martian atmosphere to violet light was less, and a weak blue-clearing was definitely detected residing in the north and generally covering the afternoon side of the globe; in other words, from the terminator to about the Central Meridian. The morning side was opaque to violet and blue light. A weak early morning limb haze and a small morning cloud just north of the equator were recorded. The formerly observed atmospheric dark streak was again evident on blue plates as a broad and diffuse band centered on the −20° parallel.

The bright white Hellas plateau gave the first impression of a south polar hood or Cap because of the northward 22° tilt of the planet.

The great Syrtis Major was a normal dark gray shade, with its northernmost tip at the Nili Lacus being a blue-green hue. The Umbra and Copais Pons were increasing in contrast from a dark gray to a black shade.

The Ismenius Lacus showed maximum contrast, with its two component oases Lysa and Elusa Fons and the area between them being a dark gray to black shade.

The Casius, Protonilus, Deuteronilus, Pierius, and the Callirrhoe canals exhibited maximum contrast during this Martian season. The Nilosyrtis was poorly seen because of its low contrast, which indicates that the darkening wave has not reached its latitude to date.

**January 12, 1965;** 1010–1418 UT; CM 268–302°; MD 16 May. The 16-inch Cassegrain telescope was used at 500× and employed a camera.

The North Cap was still bright white and cloud-free and growing smaller. The peripheral band was dark but narrow. Nothing was seen in the antarctic.

The astronomical seeing was too poor for a quality blue-clearing check. No haze or clouds were noted. The dark streak was vaguely detected extending from the terminator.

Only the bold surface features were observed and recorded in the bad seeing conditions. The Protonilus–Deuteronilus canal and the Ismenius Lacus were so prominent that they were recorded by photography in yellow light.

**January 21, 1965**; 1147–1328 UT; CM 185°; MD 20 May. The 16-inch reflector used 666× and a camera. Disk diameter 10″ of arc.

The North Cap was bright and clear and measurably smaller. Apparently a maximum melting rate has been reached. The peripheral band was broad and was a moderately dark gray shade. No antarctic whitening or haze or cloud was noted.

Extensive morning limb haze was recorded from +40° to −40° latitude in blue and violet light. No atmospheric blue-clearing was detected in violet light. A medium-altitude terminator cloud appeared brighter and sharper in blue light than in violet light with a position at about 135° long., +25° lat. ca.; which is the usual area for cloud formation over the Nix Olympica in the Amazonis desert.

The Trivium Charontis and its northern connecting canal system were well defined visually and photographically. The Trivium had below-average contrast; in fact, it was weaker than this observer has ever seen it in 16 years. The Propontis region was becoming a normal seasonal dark gray and black shade with a maximum contrast. The Scandia and Panchaia regions were filled in with the seasonal dark coloration. The Maria Sirenum and Cimmerium appeared a moderate dark gray shade.

The Cerberus, Dis, Hades, Bidis, Midas, Gyndes, and Heliconius canals reflected the seasonal darkening with excellent contrast; consequently they were easily recorded. A streak across the Scandia desert was suspected to be the Eurotus canal.

**January 23, 1965**; 1156–1415 UT; CM 166°–198°; MD 21 May. The 16-inch Cassegrain instrument was used with 666× and a camera. The 6-inch refractor was also employed with 280×.

The smaller North Cap was bright and clear and surrounded by a moderately dark peripheral melt band.

The extensive morning limb haze was still present. The evening limb terminator cloud was not as bright as formerly observed, and it appeared larger and more diffuse in violet, and not recorded in blue-green light. Two other weak cloud concentrations were recorded in blue light with the following approximate ca. locations: Cloud B, 140°, +20°; Cloud C, 120°, +45°.

Possible frost was suspected on the southern high, light regions, e.g., the Phaethontis, Electris, and Eridania.

The northern dark gross surface features and the canal-like features further reflected the seasonal darkening as described on January 21. The southern maria showed only moderate contrast and were not well recorded.

**January 26, 1965**; 1154–1218 UT; CM 136°; MD 22 May. The 16-inch reflector used 500×.

The shrinking North Cap was observed to be bright white and haze-free regardless of the poor astronomical seeing conditions encountered. No haze was observed in the antarctic.

The morning limb haze existed only in the northern hemisphere from about +10° to at least +65° latitude; however, it may have extended into the arctic region over the North Cap limb. An evening terminator cloud projection was recorded centered about +10° from the equator over the Candor–Tharsis desert. A morning cloud concentration was centered at +10° latitude over the Zephyria desert. No blue-clearing check was possible because of the poor seeing.

Only the gross dark surface features were viewed visually this night. The Mare Boreum and possibly the broad Ceraunius canal were seen.

**January 28, 1965**; 1155–1413 UT; CM 123°–150°; MD 23 May. The 16-inch reflector employed 500× and 666× Plossl oculars and a camera. Axial tilt +22°. Terminator width 28°. Disk diameter 11″ of arc.

The North Cap was still bright white and haze-free. The peripheral melt-band appeared extremely weak for the seasonal rate-of-change of the North Cap. No haze was noted in the antarctic region.

A morning limb haze was present from −40° to about +50° latitude. A morning cloud was again located at +10° latitude over the Zephyria desert. No atmospheric blue-clearing was detected in violet light. A sunset terminator cloud projection was still positioned at 80° long., +15° lat. over the Candor–Tharsis deserts. A general southern hemispheric haze band covered the disk from limb to limb.

Nothing was observed crossing the great deserts Amazonis–Arcadia, which form the "hard-seeing" side of Mars.

The darkening Mare Boreum and Propontis complex displayed excellent contrast. The southern maria appeared dark and vague on the southern limb.

**January 29, 1965**; 0845–1403 UT; CM 65°–141°; MD 24 May. The 16-inch Cassegrain employed 500×, 280×, and a camera.

The North Polar Cap was seen clear and bright and rapidly receding during the Martian spring season. The northern peripheral gray melt-band was unusually weak in contrast for the Martian season.

A morning limb haze was positioned from −30° lat. to +40°. This morning haze was less extensive and weaker in density. The evening terminator cloud projection was again present over the Tharsis desert just below the Martian Eye of Thaumasia at the position 95° long., +10° lat. ca. The cloud band appeared to be fading and to be breaking up into separate concentrations. No atmospheric blue-clearing was detected because the large amount of visible moisture made the Martian disk quite opaque to violet and blue light.

The Amazonis–Arcadia deserts were featureless. Only the Maria Acidalium and Boreum, the darkened Scandia region, and the Propontis complex were recorded in the north. The Aurorae Sinus was disappearing into the terminator and it was its usual seasonal dark gray shade. The Coprates complex was vaguely recorded because of its autumnal low contrast. The Solis Lacus appeared on a color photograph as a medium brown hue.

The Nilokeras I canal was a low contrast gray shade, with no filling in of the area between the Nilokeras I and II canals.

**January 30, 1965**; 1316–1419 UT; CM 125°; MD 24 May. The 16-inch Cassegrain used a plate camera.

The North Polar Cap appeared not as sharp as formerly observed, although it was a bright white. The peripheral melt-band was still underdeveloped for the Martian season and the rate-of-change of the North Cap. Nothing was noted on or over the antarctic region.

The blue atmospheric disk of Mars appeared spotty with bright cloud concentrations. The cloud projection was still recorded on the evening terminator over the Candor desert and just below the Martian Eye. Two other cloud concentrations have appeared over the great deserts of the Amazonis–Arcadia. The measured center of area are as follows: Cloud A, 102°, +15°; Cloud B, 135°, +20°; Cloud C, 116°, +45°. The physical size of the three clouds follows, respectively: Cloud A, 22° × 26°; B, 10° × 21°; C, 22° ×24°. The early morning limb haze was confined to a narrow limb segment about 30° areocentric, and it was less dense than observed the previous night.

The Mare Boreum and the Propontis complex were dark gray to black and displayed excellent contrast.

The Nilokeras I canal had low contrast, but it was recorded in green and red light.

**January 31, 1965**; 0950–1020 UT; CM 65°; MD 25 May. The 16-inch Cassegrain used 500× and a camera.

The shrinking North Cap was clear and bright white. No haze or frost was seen in the antarctic region.

An extensive morning limb haze persisted centered on the equator over the Tharsis–Amazonis–Arcadia desert. A rather weak, broad, and diffuse evening terminator cloud was streaked toward the center of the disk centered near the equator, with the given position: 0°, 65° long.; 0°, −20° lat. No atmospheric blue-clearing was detected in violet or blue light.

Due to the poor seeing conditions encountered only the gross dark surface detail was noted.

**February 2, 1965**; 0900–1128 UT; CM 29°–68°; MD 26 May. The 16-inch reflector used 500× and a plate camera.

The North Polar Cap was rapidly melting during the late Martian spring season; however, the Cap remained bright white and cloud-free. The north cap peripheral melt-band was still below the normal seasonal contrast No haze was seen in the antarctic region except for a morning limb haze.

An extensive morning limb haze was recorded in blue light. An equatorial violet cloud band crossed the planetary disk and connected the morning haze with the evening terminator cloud projection in violet and ultraviolet light. No atmospheric blue-clearing was found on the opaque violet disk.

No frost patches were recorded in yellow-green or orange light.

Many dark surface features were recorded in green and red light regardless of the small disk diameter of only 11 seconds of arc due to the excellent seeing conditions that prevailed. The Margaritifer Sinus was a moderate dark gray with a blue-green tint. The bold Aurorae Sinus appeared the usual dark blue-gray color.

The Mare Acidalium was slowly increasing in contrast and was also a blue-gray color. The Mare Boreum was a moderate dark gray, and was broader and darker in green light.

The Acidalius Fons and Lunae Lacus exhibited a strong dark gray contrast. The Coprates Triangle system was a normal seasonal low-contrast feature. The Nectaris Palus was a moderate dark blue-gray color, much like the Aurorae Sinus. The Solis Lacus was a low-contrast oasis. The Juventae Fons was possibly recorded in red light.

The Nilokeras I and II, the Ganges, and the Uranius canals were broad, moderately dark, and well recorded on green and red plates. The Uranius canal streaked across the Tempe desert connecting the oasis Lunae Lacus and the Ascraeus Lacus, and then becoming the Acheron canal, it was seen to continue on across the desolate Arcadia desert into the great Amazonis desert. The Jamuna canal was best recorded in red light, only vaguely recorded in green light, and connected the Aurorae Sinus to the Niliacus at the head of the Mare Acidalium. The Agathodaemon canal joined the Coprates Triangle, at the bottom of the Martian Eye, to the Aurorae Sinus. The Coprates canal, itself, joined the Melas Lacus to the Tithonius Lacus. In the Tanais area a canal was recorded joining the Acadinius Fons to the Acidalius Fons, along the western edge of the great northern Mare Acidalium. The Ceraunius canal was broad and diffuse with low contrast, and it was recorded best in green light.

Four color photographs were obtained.

**February 3, 1965**; 0940–1100 UT; CM 35°; MD 26 May. The 16-inch reflector was used with a plate camera.

The shrinking North Cap remained clear of cloud and haze and appeared bright white. No change was recorded in the abnormal low-contrast melt-band. No phenomena were noted in the antarctic region.

The morning limb haze was less extensive and less dense. The evening terminator cloud appeared the same density and in the same position. The connecting equatorial cloud band was only recorded in blue light, and not seen in violet light. No atmospheric blue-clearing was detected on the violet and blue opaque Martian disk.

No frost areas were recorded in yellow-green or orange light.

The surface features were similar to those recorded on the preceding night, except they were not as well defined due to the lower-quality astronomical seeing.

Good color images were obtained during this observational period.

**February 12, 1965**; 0918–1039 UT; CM 310°; MD 30 May. The 16-inch Cassegrain telescope was used photographically. Axial tilt +21°. Terminator width 19°. Disk diameter 12.″5.

The medium-size North Polar Cap was cloud-free and remained bright white. The abnormal arctic melt-band retained its low gray contrast shade. A possible weak haze was forming over the antarctic.

A rather dense morning limb haze covering the −20° to about +40° latitudes was recorded in blue light. An afternoon cloud was again recorded on the terminator over the coordinates 240° to 280° long., 0° to +30°, which locates the cloud over the Libya desert and Isidis Regio. The equatorial cloud band was narrow, about 15 areocentric degrees, and it connected the terminator cloud with the morning cloud and haze.

A possible weak early morning frost or ice-fog was vaguely detected in yellow-green light on the equator on the Aram or Thymiamata area.

The large and dark Syrtis Major was easily observed in integrated, orange, and yellow-green light. The Umbra, Boreosyrtis, and Copais region was taking on a fairly dark gray contrast in yellow-green and orange light.

**February 13, 1965**; 1003–1039 UT; CM 310°; MD 31 May. The 16-inch reflector employed a 500× ocular and a plate camera.

The North Cap was bright white and clear. The arctic melt-band increased its low gray contrast. A tenuous south polar haze hood was recorded in blue light. No whitening was seen in the antarctic.

A dense morning limb haze covering the −20° to +40° latitudes was again noted in blue light. The afternoon cloud was still recorded on the terminator over the Libya desert and Isidis Regio. The narrow equatorial cloud band was about 15 areocentric degrees wide and it connected the terminator cloud with the morning haze.

A possible weak early morning frost or ice-fog was detected in yellow-green light on the Aram area.

The bold Syrtis Major was well observed in integrated, orange, and yellow-green light. The Umbra, Boreosyrtis, and Copais Pons were a medium dark gray shade in orange light, and appeared more diffuse in green light.

The Ismenius Lacus was barely recorded in orange and in yellow-green light.

The Astaboras I and II, Nilosyrtis, and Protonilus canals were vaguely recorded regardless of their low contrast.

**February 14, 1965**; 0829–0950 UT; CM 294°; MD 31 May. The 84-inch Cassegrain employed 500×. North axial tilt 21°6. Disk diameter 12″6.

The North Cap was large, clear, and gray-white; with a weak peripheral dark band. An extensive south polar haze hood was observed. The South Polar Cap was not present this Martian season.

A sunset limb haze (preceding limb) was detected extending from the south polar hood northward to approximately +40° latitude. A large sunset terminator cloud was seen over the Trivium–Elysium region (200°–230° longitude). No surface frost patches were noted. No blue-clearing observation was made because of the lack of a Wratten 47B filter.

Excellent colorimetry was obtained with the large 84-inch aperture. The Mare Tyrrhenum was a definite purple with mottled brown. The Syrtis Major was a dark gray-green. The Thoth–Nepenthes canal was of medium contrast and colored gray-green. The Sabaeus Sinus appeared a dark gray. The Hellas and Noachis were a light ocher hue. Ismenius and Arethusa Lacii were dark gray. The Juturna–Euphratis Lacii were large and dark gray. Nubis Lacus and Nodus Alcyonius were a gray shade. The Wedge-of-Casius and the Boreosyrtis were a dark blue-gray hue. The many canal-like features that were observed were a colorless gray shade, and are listed as follows: Callirrhoe–Pierius, Euphrates double canal system, Deuteronilus, Protonilus, Phison–Vexillum, Astaboras I and II, Astusapes, Arosis, Nilosyrtis, Thoth, Casius I and II, and Alcyonius.

**February 15, 1965**; 0938–1044 UT clouded out. 1156–1240 UT; CM 290°–328°; MD 1 June. The 84-inch Cassegrain employed 500×.

The south polar hood has become extensive, covering the southern parts of the Hellas, Noachis, and Argyre I regions down to latitudes −20° and −30°. The North Cap was large and gray-white with a weak peripheral band.

A bright sunset limb cloud and haze were noted over the Elysium and Aethiopis deserts. A bright white evening haze and possible frost area was seen over the Isidis Regio and Nubis Lacus area. A bright frost patch was located next to the preceding Mare Acidalium border in the Cydonia desert just above the Novem Viae oasis. No atmospheric blue-clearing was observed on the Martian disk. The equatorial cloud band was still present on the blue disk.

The Syrtis Major was a dark green color. The Wedge-of-Casius and Copais Pons were a dark blue-gray mixed with brown. Mare Acidalium was a weak hue of blue-green. The Margaritifer Sinus was a blue-green hue to dark gray shade. The Sabaeus Sinus was noted a dark gray shade. Canals were observed to be a colorless gray shade, and are listed as follows: Callirrhoe–Pierius, Deuteronilus, Protonilus, Astaboras I and II, Phison, Vexillum, Astusapes, Djihoun, Gehon and Thoth. The double Thoth–Nepenthes canal and Nodus Laocoontis–Alcyonius areas deserve special mention, because the Wedge-of-Casius, Thoth canal, Alcyonius, and Laocoontis were unseasonally well developed. Apparently the Laocoontis region was becoming active and colorful once again during this apparition.

Much darkening activity and expansion into the ocher desert were recorded in the Nodus Laocoontis and the Aetheopis–Amenthes desert region. The Eunostos I and II canals, radiating from the Laocoontis, were moderately broad, dark, and well defined. The Pallas canal, if the identity is correct, joining the Moeris Lacii on the Nepenthes canal with the Syrtis Minor, was also large, dark, and well defined for the given Martian season.

**February 16, 1965**; 0946–1047 UT; CM 280°; MD 1 June. The 16-inch reflector used a 500× ocular and a plate camera. The axial tilt is 21°. Terminator width 17°. Disk diameter 12″7 of arc.

The north polar crystallized cap retained its bright white and clear character. The peripheral melt-band section of arc in the Copais Pons and Boreosyrtis region was a reasonably broad and dark contrast feature because of the local seasonal darkening taking place. A fairly extensive and high-level antarctic hood was recorded visually and photographed in blue, violet, and ultraviolet light. The antarctic haze was especially bright and dense over the Hellas plateau.

The same morning limb haze and evening terminator cloud were again recorded this night. The equatorial cloud band was still present, and it seemed to measure slightly southward by about $-10°$ from its former position. No blue-clearing was detected in violet or ultraviolet light.

A possible early morning frost area was noted in yellow-green light on the Aram or Thymiamata area at about 12° long., $+18°$ lat. ca. The gross, dark surface features appeared a little fuzzy in yellow-green light. Yellow-green and orange light indicated a bright white spot on the northern Hellas plateau.

The grand Syrtis Major was a well defined feature in orange light, and it appeared a dark gray to a very black-green hue in integrated light. No canal-like structure was noted traversing the Syrtis. The ever darkening Umbra, Copais, and Utopia regions were a dark blue-gray. The Mare Serpentis was a Sabaeus Sinus blue-black. The Maria Tyrrhenum and Iapygia were a mottled brown and dark purple.

The Nodus Laocoontis–Alcyonius complex was a moderate gray contrast, but it was a well developed and well defined region, considering the early season. The Moeris Lacii, on the Nepenthes canal, were extremely dark and well developed, with an enlarged and dark canal structure giving the area a strange straight appearance.

The Thoth–Nepenthes canal appeared double, although it was filled in with a lower-contrast substance. The Eunostos I and II canals and the Adamas or the Aethiops canal were recorded radiating from the active Nodus Laocoontis. The short Pallas canal was broad and dark. The Astaboras I and the Nilosyrtis canals were definitely recorded, while the Astusapes canal was suspected. The Vexillum was also noted in the Arabia desert. Canal frequency was beginning to increase.

**February 17, 1965;** 0830–1344 UT; CM 250°; MD 1 June. The 16-inch Cassegrain and 6-inch refractor employed 666× and 286×, respectively.

The same, extensive south polar hood was still present. The North Cap was clear of cloud and haze, and appeared smaller.

No blue-clearing was observed. The northern part of the Elysium had turned white, and was best noted in yellow-green (W-57) light.

The Moeris Lacus was dark and swollen. The Nubis Lacus area was faint and small, while the Nodus Laocoontis–Alcyonius–Thoana area was large and a moderate dark gray.

**February 18, 1965;** 0750–0920 UT; CM 231°–253°; MD 2 June. The 16-inch Cassegrain and 6-inch refractor used 666× and 280×, respectively.

The North Cap was rapidly shrinking. The south polar region was still covered by an extensive polar hood.

Much cloud, haze, and frost were noted on the Martian disk. No atmospheric blue-clearing was detected. The entire Elysium was a brilliant white shade in yellow-green light. A faint blue cloud was detected over the Elysium.

Apparently the Trivium had not darkened this season because it was not its usual black shade and blue-black hue, but was a light brown color, very unusual, indeed. The southern maria were exhibiting color changes, i.e., dark blue, purple, and blue-gray hues. The Syrtis Major was a dark blue-green.

The double Thoth canal system was broad and dark, with the area between the double canal system darkly filled in. The Nodus Laocoontis–Alcyonius complex was still unusually large and moderately dark showing normal seasonal contrast. The radiating Aethiops and Amenthes canals were extremely well developed and broad in red light for the given Martian season. The Pallas was large and dark and easily recorded in orange and red light, but poorly recorded in green light, indicating a color trend toward the green. The surrounding Aethiopis desert in the vicinity of the above swollen canals and the Nepenthes canal exhibited much filling-in and darkening structure, giving the appearance that the curved Nepenthes canal is straight at the top in the vicinity of the Moeris Lacus and leads off east connecting to the Mare Cimmerium at the Tritonis Sinus with a new canal-like feature. This previously large and dark area (1954–1958) has faded and decreased in extent only in the Thoana Palus area to the north and northeast.

**February 19, 1965;** 0748–1248 UT; CM 223°–269°; MD 2 June. The 16-inch Cassegrain and 6-inch refractor employed 320× and 280×, respectively.

The North Cap was clear of haze and clouds. The south polar hood was massive and seen extending northward into the Hellas region.

The Elysium was observed to be white and brighter than the North Polar Cap in yellow-green light.

A round-shaped cloud was recorded over the Elysium in blue and violet light. Large sunrise and sunset limb blue-violet clouds were recorded photographically. No atmospheric blue-clearing phenomenon was observed.

The surface features appeared the same as observed on the preceding night.

**February 20, 1965;** 0636–0911 UT; CM 197°–233°; MD 3 June. The 16-inch Cassegrain used 666× and 600× and cameras.

The astronomical seeing was excellent this evening. The recorded Martian disk features were the same as on the two preceding nights.

The Elysium was totally covered with brilliant, white frost. The Trivium persisted as a light to medium brown color. The Styx, Dis, and Hades canals were weakly observed. Yellow-green (W-57) light recorded the surface features vaguely, as if a green veil were drawn over the 130° to 260° longitudes. The double Thoth canal was broad and increasing in contrast. No blue-clearing was noted on the Martian disk.

**February 21, 1965;** 1038–1200 UT; CM 243°–266°; MD 3 June. The 16-inch Cassegrain operated at 320× and employed a plate camera.

The North Cap was still cloud-free and steadily shrinking in size, exhibiting the associated medium-contrast dark peripheral band. The south polar hood was less extensive, but still large and bright in blue light.

Large and intense clouds had formed, extending from the sunrise limb, along the equator, to the sunset limb. The Trivium–Amazonis region was ill-defined in yellow-green (W-57) light.

The only change recorded in the surface dark features from the preceding night's observation was the darkening of the Nodus Laocoontis oasis area.

**February 25, 1965;** 0725–0821 UT; CM 165°–177°; MD 5 June. The 16-inch Cassegrain and 6-inch refractor employed 666× and 286×, respectively.

The North Polar Cap was clear of cloud and haze, and much smaller than recorded during the last observation on the night of February 21. The north cap peripheral band was not as dark as it normally is for this Martian season. The south polar haze hood was observed to be smaller and less dense.

A large sunset limb cloud was located on the equator. Sunrise frost was still present on the Elysium. Less atmospheric cloud activity was noted. The equatorial cloud band was weak in blue light. An atmospheric "green-haze" was again suspected in the Arcadia, Amazonis, Cebrenia, and Elysium regions. No blue-clearing of the Martian atmosphere was detected.

The southern maria had darkened since they were last observed. The Trivium was still only a medium brown hue.

**February 26, 1965;** 0647–1357 UT; CM 147°–249°; MD 5 and 6 June. The 16-inch Cassegrain used 500×.

The North Cap appeared a yellow-white, and was still decreasing in size. A weak south polar haze was detected.

Three large, dense, evening clouds were seen forming over the Amazonis desert, which is a normal seasonal formation at their respective areographic coordinates. Early morning, high-altitude clouds and frost were seen in the Trivium–Elysium region. The Elysium frost plain appeared brighter than the North Cap. Heavy morning cloud was observed over the Aeria, Meroe Insulae, and Crocea deserts, and possible frost on the Neith Regio desert. No atmospheric blue-clearing was detected during the entire night. Dense clouds and general atmospheric haze were detected in yellow-green light, which is a rather unusual phenomenon, indeed. Yellow-green light has always penetrated the Martian atmosphere and recorded the surface features or the low fog-type haze or yellow dust clouds; normally it does not record the higher-level blue-type clouds. The same three blue-type cloud concentrations plus haze were recorded in yellow-green light in the areographic longitudes from 90° to 265°. The Syrtis Major, at 290° longitude, appeared only slightly hazy in yellow-green light, while the east side of the Thoth canal, the Nodii Laocoontis–Alcyonius, and the Trivium Charontis were recorded very poorly in yellow-green light. Was the green opacity due to visible moisture at medium to low altitude or to atmospheric ocher dust particles from a dust storm? Three yellow-green cloud concentrations were recorded at the following center-of-area positions: Cloud D) 111°, +15°; Cloud B) 136°, +19°; Cloud C) 117°, +46°.

No change in the dark surface features was observed. The Syrtis Major was a gray-green to blue-green color.

The Nodus Laocoontis oasis was growing larger and becoming a different hue relative to the increasing broad Thoth canal, which was a medium to dark gray shade.

**February 27, 1965;** 0625–0656 UT; CM 135°; MD 6 June. The 16-inch Cassegrain employed 500×.

The North Cap still had a yellow-white color. No south polar haze hood was detected this evening.

Five well defined blue cloud concentrations were recorded over the Tempe, Tharsis, Arcadia, and Amazonis deserts, as well as cloud and heavy sunrise limb haze over the Zephyria and Elysium regions. These five cloud concentrations became large, diffuse, and connected in yellow-green light. In fact, the entire Martian disk was covered with a green, opaque haze, with the greatest opacity residing in the southern hemisphere. The "green-haze" was found in the same hemisphere from about 80° to about 260° longitude, and the atmospheric opacity to yellow-green light was increased over the previous night. The atmospheric opacity in blue-green light appeared identical to that in broad blue light. The coincident blue and yellow-green five cloud concentration ca. coordinates are as follows: Cloud A) 95°, +12°; Cloud B) 136°, +19°; Cloud C) 117°, +46°; Cloud D) 111°, +15°; Cloud E) 161°, +2°. There were other smaller and weaker cloud concentrations also noted on the blue and violet disk of Mars. No atmospheric blue-clearing was detected on the disk of Mars.

The Elysium was still covered with frost.

The Trivium was rather diffuse and of low contrast. The dark surface features were not clearly defined.

**March 1, 1965;** 0737–1303 UT; CM 133°–206°; MD 7 June. The 16-inch Cassegrain employed a 500× ocular and a plate camera. Axial tilt +21°. Terminator width 7°. Disk diameter 13″.7 of arc. Nine days from opposition.

The North Polar Cap was rapidly decreasing in size. It appeared a dull white and clear of blue cloud and haze. The peripheral melt-band was not seen as a separate entity. A south polar hood was not seen.

An evening limb cloud was seen at 130°, +20° ca. over the Arcadia desert. Morning limb cloud and haze were recorded over the Elysium plateau, Zephyria desert, and Cebrenia desert. No atmospheric blue-clearing was noted.

Yellow-green light indicated early morning frost on the Elysium plateau. The "green-haze" opacity was still strong in the south and in the Arcadia–Amazonis desert region, with only the dark Propontis complex being vaguely recorded in yellow-green light.

No surface features were noted in orange or red light in the Arcadia–Amazonis desert region. The Propontis–Scandia region was seasonally well developed and the oases were becoming a very dark gray to black shade. The Propontis was strongly recorded in red light.

**March 2, 1965;** 0650–0725 UT; CM 115°; MD 8 June. The 16-inch reflector employed a plate camera.

The rapidly shrinking, small North Cap appeared to be a dull yellowish-white color, and it was not well recorded in orange or red light. The peripheral melt-band was extremely faint and thin and was a rather dark ocher hue. No haze or cloud was observed over the antarctic region.

A large and diffuse blue-white afternoon cloud was located over the Chryse desert centered on the Equator. A very weak equatorial cloud band was noted. A sunrise haze and a cloud concentration were seen best in blue light over the Zephyria desert and the Elysium plateau, respectively. The Martian atmosphere was generally opaque to yellow-green light in the Tempe–Arcadia–Amazonis desert region, with only the dark Propontis complex being obscurely recorded, thus indicating that "green-haze" was still present.

Absolutely nothing was observed across the broad expanse of the Arcadia–Amazonis desert. The southern maria and the Propontis oases were recorded best in red light.

The Nilokeras I and II canals were noted to be broad and a moderate dark gray shade.

**March 4, 1965;** 0800–0835 UT; CM 115°; MD 8 June. The 16-inch Cassegrain instrument was used with 666× and 280× and a plate camera.

The small North Cap appeared to be a very ocher desert orange color. The peripheral melt-band was not noted, which is unusual for the given Martian season and fast rate-of-change of the melting Polar Cap. A small polar cloud was recorded best in violet light and vaguely in blue light at position 104°, +70° ca. A weak cloud was recorded in violet light on the sunset limb in the antarctic region.

Much cloudiness and haze were recorded in the Martian atmosphere in violet, blue, and yellow-green light. A sunrise haze was recorded from −12° to +45° latitude. Blue and violet light cloud concentrations were measured at the following ca. positions: Cloud A) 113°,

+15°; Cloud B) 136°, +20°; Cloud C) 118°, +41°; Cloud D) 88°, +10°. The Martian atmosphere was extremely opaque to violet, blue, and green light; consequently, no blue-clearing was found on the disk.

The observing period was clouded out before surface detail could be recorded.

**March 6, 1965;** 0705–1123 UT; CM 82°–135°; MD 9 June. The 16-inch reflector was employed using a plate camera. Axial tilt +21°. Disk diameter 13''.9. Three days from opposition.

The small North Polar Cap was still an ocher desert color, and it was not recorded in orange or red light. Could the North Cap's color and obscureness over the past several days be due to an arctic dust or sandstorm? The peripheral melt-band was also obliterated and not seen. No antarctic haze was recorded in violet or blue light.

The four cloud concentrations were again recorded at the same positions in violet and blue light, although they appeared nebulous and not as well defined. A general haze was recorded over the disk of Mars at the 135° CM longitude. The morning haze still covered about the same latitudes −12° to 40° as measured on March 4. An atmospheric blue-clearing was suspected in the far north, but it was not confirmed. The northern longitudes east of 80° appeared much more cloud- and haze-free, and the atmospheric opacity to violet light was decreasing in the extreme north around the coordinates 40° long., +50° lat. The "green-haze" still chiefly persisted in the Arcadia–Amazonis region 90° to 170° long., +80° to −5° lat.

The Mare Acidalium was recorded as a dark gray shade in the afternoon sunlight with dark gray-green oases concentrations. The southern maria were poorly defined in green and red light.

The darkening Nilokeras I and II canals and the broad double Ganges canals were observed. A faint hint of the Ceraunius canal was noted in red light. The Tanais canal and the Acidalius Fons were quite intense black, and exhibited excellent contrast with the ocher Tempe desert.

**March 8, 1965;** 0624–1139 UT; CM 52°–128°; MD 10 June. The 16-inch Cassegrain instrument used 490× and 666× oculars and a plate camera. Axial tilt +21°. Terminator width 3°. Disk diameter 13''.9 of arc.

The North Polar Cap was steadily shrinking in physical size, about 22° in diameter, round and uniform in physical structure, clear of haze or cloud, photographed in orange and red light, and with a more normal white shade. The arctic region was extremely free of cloud and haze. The northern peripheral melt-band was once again detected as a fine moderate dark gray line surrounding the North Cap arc. The antarctic was also clear of cloud and haze.

The atmosphere of Mars was extremely clear of cloud and haze in the 0° to 90° longitudes. A weak morning limb haze was recorded over the Arcadia desert only in blue and violet light. A broad and weak sunset limb cloud was recorded over the Eden desert in violet light. A medium atmospheric blue-clearing was recorded in the 0° to 100° longitude, +40° to +90° latitude region. The Maria Acidalium and Boreum and the Ceraunius canal were observed strongly through the Martian atmosphere in blue and violet light.

A weakening "green-haze" was observed in the Tempe–Arcadia–Amazonis desert region. No "green-haze" was detected in the Eden–Cydonia–Acidalium region. No areas of frost were noted in these longitudes of observation.

The Maria Acidalium and Boreum were clearly recorded in orange and red light, with dark oases concentrations at Acadinius and Acidalius Fons. The Baltia area and the central section of the Mare Acidalium were extremely large and dark gray-green. In the southern hemisphere the Margaritifer and Aurorae Sinus appeared dark gray. The Solis Lacus was fairly large and moderately dark gray.

The canals Nilokeras I and II, Phryxus, the Ganges, Tanais, Nilus, Ceraunius, and Agathodaemon were recorded in yellow-green, orange, and red light.

**March 9, 1965;** 0630–1220 UT; CM 45°–131°; MD 11 June. The 30-inch USGS Cassegrain at 666× and 800× and a camera and the 16-inch TMO reflector at 666× and a plate camera were employed. Mars was at opposition with a disk diameter of 14'' of arc, and an axial tilt of +21°.

The North Polar Cap appeared clear, bright-white, symmetrical, and rapidly decreasing in size over the past eight days. The peripheral melt-band was dark and thin in width. A weak antarctic haze was noted.

A blue cloud was recorded on the sunrise limb over the Amazonis desert. A weak morning limb haze was noted from about −10° to +45° latitude. A sunset limb cloud or frost patch was located on the equator over the Edom area. A decreasing atmospheric blue-clearing was detected in violet light in the Mare Acidalium region.

The Mare Acidalium was generally a dark gray shade, and a dark gray-green hue was noted in the central area and at large oases junctions within the Mare itself. The Aurorae Sinus was a dark blue-gray to dark gray shade.

The Coprates Triangle system of oases and canals was dark, with the enclosed desert area filled in. The dark gray Propontis complex was poorly observed, particularly in yellow-green light. The Solis Lacus was large and a medium dark gray shade. The "green-haze" was becoming weaker in the Arcadia–Amazonis region.

The Nilokeras I and II, Nilus, Ceraunius, Tanais, and double Ganges canals were clearly observed. No canal-like features were noted crossing the Amazonis desert.

**March 10, 1965**; 0453–1159 UT; CM 13°–118°; MD 11 June. The 30-inch and 16-inch Cassegrains used 400×, 490×, and cameras.

The melting North Cap had reached its greatest rate-of-change, and it was small and symmetrical and white. A possible morning haze was seen in the arctic region. The peripheral melt-band was thin and a dark gray shade. A weak south polar hood was observed best in blue (W-38) and blue-green (W-64) light, indicating an intermediate altitude.

The Aeria and Arabia deserts were covered by sunset blue clouds, but they were noted clearly in orange and red light. A morning haze extended from about the equator into the arctic region. A weak atmospheric blue-clearing was still detected in the northern hemisphere over the Maria Acidalium and Boreum. The dark contrast of the Mare Acidalium could even be traced in the ultraviolet. The "green-haze" was becoming less intense in the Arcadia–Amazonis longitudes.

A small sunrise frost patch was located near the equator on the Tharsis desert. The Aram area appeared a light ocher color between the darker Sabaeus Sinus and Margaritifer Sinus.

The Mare Acidalium was a very dark gray shade with a black-green central area and large dark gray-green oases. The southern maria were gray-blue hues. The Margaritifer was not clearly defined. The northern maria were increasing in contrast and exhibiting seasonal darkening color changes.

The canal structure was recorded as follows: The Nilokeras I and II, the double Ganges, Nilus, Ceraunius, Tanais, Indus, and the double Gehon I and II.

**March 15, 1965**; 0830–1100 UT; CM 23°–60°; MD 13 June. The 30-inch Cassegrain was employed using 500× and a camera. Disk diameter 14″ of arc.

The North Cap was well recorded in blue, green, orange and integrated light. The Cap was white and symmetrical in outline, with a weak high-altitude blue haze over part of it. The north melt-band was increasing in contrast and appeared as a thin dark gray line in the vicinity of the Maria Acidalium and Boreum.

A weak equatorial cloud band appeared in blue and violet light with about a 20-areocentric-degree width that traversed the entire planetary disk. A morning haze extended from −15° lat., just below the Martian Eye (Solis Lacus), across the Tharsis desert, to about +50° lat. The Mare Acidalium was recorded in violet and blue light, indicating that the blue-clearing phenomenon still existed in the northern hemisphere. The "green-haze" made the Martian atmosphere moderately opaque to yellow-green light in the Arcadia–Amazonis desert region; consequently, little surface structure was recorded in this region at this wavelength. Afternoon frost was indicated in yellow-green light to lie on the Aram, Aeria, and on the relatively new area Nix Cydonia located on the preceding border of the Acidalium just north of the Novem Fons. The Noachis was a very light ocher hue.

Many fine surface details were recorded in orange, red, and integrated light during this period of good astronomical seeing. The seasonal darkening and color changes were progressing southward and had just about reached the equator.

The southern Sinus Sabaeus, Meridiani, Margaritifer, and Aurorae, and Mare Erythraeum were a winter medium-contrast gray-blue shade. The grand Mare Acidalium was a swollen dark gray-green hue with a black-green central area and many dark green oases concentrations. The Achillis area, separating the Mare Acidalium from the Niliacus complex, was an arched, light ocher hue feature. A light ocher area separated the black Baltia from the Acidalium. The Fastigium Aryn was well defined.

Many small dark oases appeared in the Acidalium region that were not named on existing charts of Mars. The Niliacus Lacus consisted of six dark oases: three temporary unmapped Fons, and the Endor, Engedii, and the Jordanis Fons. The Achillis Fons and Lunae Lacus were a dark gray and increased in size in tune with the seasonal darkening-wave. The Aromatum Prom or Aurorae Prom was well developed and appeared as a medium gray oasis detached from the southern maria. The Oxia Palus was becoming large, dark, and irregular, and it was easily photographed in orange and red light. The Ismenius and Arethusa Lacii were long and dark, contrasting easily with the contiguous deserts. In the Mare Acidalium, the black-green Novem, Acadinius, and Acidalius Fons were the largest and darkest of the oases. Several temporary, small, oases darkenings were located across the top or south border of the Acidalium. The dark gray Mare Boreum did not have the contrast of the Acidalium. The Ascraeus Lacus, in the Tharsis desert, was elongated and appeared to be double and exhibited a medium contrast. The Achillis Fons was differentiated along the Nilokeras I canal.

The following gray canal structures were recorded: The broad and double Ganges, Nilokeras I and II, Uranius, Acheron, Indus, Oxus, Gehon I and II, Hiddekel, Dardanus, Eulaeus, Tanais, Laxartes, Callirrhoe, and Chrysorrhoas. The Eulaeus canal was seen to traverse the dark Mare Acidalium and join with the Tanais canal. The Phryxus canal hasn't been seen recently because the area between the Nilokeras I and II canals is filled in with seasonal darkening.

A new, broad canal was photographed on the following or west side of the Acidalium crossing the Tempe desert and connecting the Acidalius Fons with the Achillis (Craneum) Fons. This rather broad canal is not registered on historical maps of Mars that are available to the writer, and it vaguely appears as an unnamed feature on only one modern map drawn by Siro Ebizawa of Tokyo in 1956, which is an updated version of E. M. Antoniadi's 1929 map. It will hereafter be referred to as the Tempes canal.

**March 16, 1965**; 0524–1036 UT; CM 328°–44°; MD 14 June. The 16-inch Cassegrain used 320× and a camera.

The relatively small North Cap was white and symmetrical with a high-altitude haze noted in violet light. The Cap was poorly recorded in orange and red light. The peripheral melt-band was only a thin gray line surrounding the North Cap. Violet and blue light recorded a cloud at the approximate position 280° long.; −40° lat., which puts it over the northern part of the Hellas plateau.

A sunset cloud was located over the Aethiopis–Libya region. A broad and weak equatorial cloud band crossed the entire Martian disk from 40° to 260°. A morning limb haze was present over the Arabia to the Chryse desert. The atmosphere was still weakly transparent to violet-blue light in the northern hemisphere in the vicinity of the Mare Acidalium, indicating a possible weak blue-clearing. Limb haze was the only visible moisture in the longitudes 110° to 330°. The atmospheric "green-haze" appeared weaker in the 80° to 110° longitudes. No green haze was apparent in the 70° to 260° longitudes.

The northern part of the blue-green Syrtis Major was showing a color contrast increase. The Sabaeus Sinus was its usual dark gray to blue-black shade. The Mare Acidalium was a dark gray-blue with dark-green oases variegation.

The Nilokeras I, Nilokeras II, and Protonilus canals were vaguely recorded.

**March 17, 1965**; 0553–1109 UT; CM 330°; MD 14 June. The 16-inch Cassegrain and 16-inch refractor used 500× and 286×, respectively, and a plate camera. The axial tilt was +21°. The disk diameter was 14″ of arc.

The North Cap was a beautiful dull white compass with the possibility of a weak arctic haze over the southern extremity. The melt-band was barely perceptible. A low cloud or haze was again present over the Hellas plateau in the southern region. No antarctic haze was seen.

The Martian atmosphere was generally hazy. A sunset cloud was located over the Aethiopis–Laocoontis region at 0° to +30° lat. The equatorial cloud band was not as wide as formerly observed. A sunrise cloud concentration was located over the Chryse desert along with lower-level early haze. The atmospheric opacity to violet light had returned to normal, at least in the observed longitudes; therefore, no blue-clearing was detected.

Green and red light indicated frost on the Hellas plateau.

The Syrtis was still a blue-gray-green with the northeastern border and tip a dark gray to black. The Mare Tyrrhenum appeared a dark brown hue. The Sabaeus Sinus was a dark blue color. The Meridiani Sinus

(Furca), at the end of the Sabaeus, was an intense black shade. The Mare Serpentis was also a dark gray shade, and it was well defined in orange light even though it was high up on the southern limb. The Deltoton Sinus was only a medium gray shade. The Hammonis Cornu was a normal light shade. The Umbra and Copais Pons were quite dark gray. The Wedge-of-Casius and Boreosyrtis contained lighter areas within themselves.

The Ismenius Lacus was an elongated, large, and dark feature.

The Protonilus and the Deuteronilus canals were seen connecting to the Ismenius Lacus. The Pierius canal was vaguely recorded. In the south, the Poras canal was prominent and connected the Deltoton Sinus with the Sabaeus Sinus.

**March 18, 1965**; 0430–0555 UT; CM 305°; MD 15 June. The 30-inch USGS Cassegrain was used with a camera and a 400× ocular.

The North Polar Cap appeared to have stopped its shrinking or melting rate, and it appeared bluish. A blue evening limb and polar haze were recorded over the North Cap in blue-green, blue, and violet light. The melt-band was thin and weak. A possible weak antarctic haze was noted in blue-green, blue, and violet light.

The Martian atmosphere showed much cloud activity. A large evening cloud was located over the Aethiopis–Elysium region. Evening limb haze was seen from about −3° to 90° latitude. An equatorial cloud band crossed the entire planetary disk. Morning haze was located over the Chryse desert from 0° to about +30° latitude. No blue-clearing was noted in violet light.

An Elysium whitening was seen best in yellow-green light and not in blue-green light. The Hellas appeared white in yellow-green light. A large frost or ice-fog was located in the Oxia–Cydonia desert adjacent to the eastern border of the Acidalium.

Many color changes were appearing in the maria. The Maria Hadriacum and Ionium had changed from a moderate gray-brown to a yellow-brown and a peculiar dark pea-green hue contiguous to the white Hellas plateau was seen. The Maria Tyrrhenum and Iapygia were a definite purple and varicgated brown color. The Pandorae Fretum had a purple-brown appearance. The Sabaeus Sinus was a dark blue-gray to black color. The Meridiani Sinus was an intense black, exhibiting maximum contrast. The Hammonis Cornu was a light shade. The Deucalionis Regio was a strong ocher hue. The Crocea–Cenotria, separating the Syrtis Major from the Iapygia, was a desert ocher hue. The gross Syrtis was a well saturated, dark blue-gray color, with the northeastern border and northern tip a darker gray shade. The Isidis Regio and the Arabia deserts were a normal ocher color. The Aeria desert was a brighter yellow-ocher hue, in contrast to the dark blue-gray Syrtis. The Casius, Umbra, and Copais Pons had a dark blue-gray tint. The Utopia area between the traversing canals was a dark ocher color. The Dioscuria was a desert ocher color. The Fastigium Aryn was evident.

The Moeris Lacus appeared as a dark gray knot within the broad Thoth, and it was becoming larger with increasing contrast. Thc Ismenius Lacus was fairly large and blue-black. The Nodus Laocoontis was observed through the evening clouds on the sunset limb.

The gracefully curving Thoth–Nepenthes canal was a double medium-gray feature with its two canals becoming blue-gray as they fanned out across the Casius–Utopia region. A hint of the Astaboras I canal extension was noted on the western border of the Syrtis. The Protonilus, Deuteronilus, Arnon, Pierius, and Callirrhoe canals were easily seen during the Martian spring season. The Alcyonius was noted to have a slight blue-gray tint. No canals were seen crossing the Arabia–Eden deserts.

**March 19, 1965**; 0515–1051 UT; CM 302–22°; MD 15 June. The 30-inch and 16-inch Cassegrains were used with cameras and 450× to 800×.

The North Cap was a dull, gray-white oval with a blue haze tint. The physical size of the Cap was the same in red light as noted on the former two nights. Observation through 140° longitude rotation of the planetary disk showed the Cap to be an elongated or elliptical shape, with the major axis points lying on about the 20° and 200° longitude positions. The North Cap melt-band was a thin line and appeared a low-contrast gray shade through the arctic haze. An evening limb haze and a weak arctic polar hood were detected in blue and violet light, but best in blue and blue-green light, which indicated a medium atmospheric level. A weak antarctic hood was observed to be denser at CM 0° longitude than at CM 300° longitude.

The Martian atmosphere contained much visible moisture during this period of observation. A large cloud was recorded in blue and violet light over the Elysium plateau. A thin, small morning haze was noted over the eastern edge of the Chryse desert. An equatorial cloud band, 20 areocentric degrees wide, crossed the Martian disk from 230° to 87° longitude. An evening cloud was evident over the Arabia desert, stronger in blue than in violet light. A large and diffuse cloud concentration was recorded strongly in blue light and less intensely in violet light over the Tharsis desert, just below the Martian Eye. A morning limb haze was seen from −10° to +40° latitude. A possible blue-clearing was evident in the Mare Boreum area from 40° to 85° longitude, although not confirmed.

The Hellas plateau was completely frost covered, as it appeared bright in yellow-green and orange light. Part of the Aeria desert, and particularly in the Nymphaeum area, was observed to be yellow-white.

The southern gross dark maria appeared the same as recorded formerly. The Hammonis Cornu was a lighter shade in contrast to the Deltoton Sinus and the Sabaeus Sinus. The Deucalionis Regio was its normal light ocher hue. The Dioscuria desert was sharply outlined by the dark Umbra area, and the Protonilus, Arnon, and Pierius canals. The Mare Acidalium had an extremely dark green central core and black-green oases within.

The Moeris Lacus was a dark double oasis. The Nodii Laocoontis and Alcyonius were seen as good-contrast dark features. The Antigones Fons was a noticeably dark gray shade. The Ismenius Lacus was observed showing its double character, the Lysa and Elusa Fons. The dark Oxia Palus had an irregular triangular shape. The Endor, Engedii, Jordanis, Acadinius, Novem, and Acidalius Fons were observed easily. The Niliacus and Lunae Lacii were fairly large and showed good contrast with the ocher Tempe–Xanthe deserts. The Sigeus Portus was evident on the northern edge of the Sabaeus Sinus. The Fastigium Aryn was clearly defined in the bay of Meridiani Sinus (Furca).

A list of the observed canal features follows: Thoth–Nepenthes (double), Typhon (vague), Phison (double and vague), Nilosyrtis (northern part), Alcyonius, Protonilus, Deuteronilus, Pierius, Callirrhoe, Casius, Euphrates (double and vague), Gehon I, Oxus, Indus, Dardanus, and the Nilokeras I and II.

**March 20, 1965**; 0340–0953 UT; CM 273°; MD 16 June. The 30-inch and 16-inch Cassegrains used 450× and 800×. Disk diameter 13″.8.

A weak north polar haze was seen over the North Cap. The North Cap appeared to have halted its melting rate. A very weak south polar low-altitude haze was detected in blue-green versus yellow-green light over the frost-covered Hellas.

Atmospheric cloud activity and numerous frost areas dominated this observational period. Heavy cloud was observed over the Trivium and the frost-covered Elysium on the evening limb. Heavy morning clouds were noted over the Eden, Arabia, and Aeria deserts. Bright frost covered most of the Aeria desert, and white frost on the Isidis and Neith Regios persisted through high noon. Early morning frost was located on the Eden desert. No blue-clearing was detected.

The Maria Tyrrhenum and Cimmerium were a purple-brown color in contrast to the bright blue Syrtis Major. The Umbra, in the Wedge-of-Casius, was a very dark gray shade and began to take on a slightly green tint.

The broad, double Thoth canal was a dark blue-gray hue, with the Nodus Laocoontis oasis, on its preceding side (251° long.), exhibiting a color change toward green. The Nar–Chaos and Eunostos I and II canals were clearly observed joining the Thoth to the Trivium Charontis and outlining the Elysium plateau.

**March 21, 1965**; 0449–0740 UT; CM 277°–318°; MD 16 June. The 30-inch Cassegrain and 16-inch Cassegrain employed 400×, 500×, and 666×, and cameras.

The North Polar Cap was clearly seen through the haze hood with a narrow, dark peripheral band extending from about 290° to 10° longitude. No change was detectable in the physical size of the North Cap. No south polar haze hood was detected this evening. No sign of the South Polar Cap, only the bright, white pseudo cap of the Hellas plateau was observed.

The atmospheric cloud activity was much less on this date. An evening limb cloud was located over the Elysium and Aeolis regions. Frost was observed on the Elysium in the evening, and on the preceding border of the Mare Acidalium on the Nix Cydonia in the Cydonia desert on the morning limb. A possible weak blue-clearing was reported confined to the southern hemisphere in the Maria Cimmerium, Tyrrhenum, and Sabaeus regions.

The Syrtis was a brilliant blue color. The Mare Tyrrhenum was a purple-brown hue. The Sabaeus Sinus was a dark gray shade with no color hue noted within the dark region.

The Thoth canal was a blue-gray; also, the Nubis Lacus within the Thoth was of the same hue. The Nodus Laocoontis was becoming a large, dark green area. The Moeris Lacii were a black-green hue.

The fine canal-like features were becoming prominent during this Martian season. The observed canals were as follows: Rhesus–Astusapes, Astaboras I, Phison–Vexillum, Euphrates, Hiddekel, Deuteronilus, Protonilus, Djihoun, Callirrhoe, Pierius, Casius, Heliconius, Nilosyrtis, and Alcyonius. Observed oases were recorded as follows: Moeris Lacii, Lysa F. and Elusa F. of Ismenius L., Astaborae F., Coloe P., Antigones F., Nodus Laocoontis, Nubis Lacus, Nodus Alcyonius and Sithonius Lacus.

**March 23, 1965**; 0535–0830 UT; CM 281°–323°; MD 17 June. The 30-inch Cassegrain telescope used 500×.

The North Cap still appeared to be about the same diameter as recorded during the observation of March 20; in fact, it measured slightly larger from new deposits because the north polar hood was still very much in evidence.

Clouds and frost were on the evening limb in the Trivium–Elysium region. No blue-clearing was detected in the Martian atmosphere. The atmospheric moisture was apparently high this evening because of the cloud and frost activity. Heavy morning cloud and frost were located on the Eden–Aram deserts. High-noon frost was observed on the Neith–Isidis Regio and on the Nymphaeum plateau. The Hellas plateau was a brilliant white, contrasting beautifully with the bright blue Syrtis Major.

Three dark ocher areas were evident in the Wedge-of-Casius region: one located between the Umbra and Copais Pons areas, another located between the Casius and Heliconius canals, and the third located between the canals Alcyonius and Heliconius next to the Sithonius Lacus. These surface features had reached their greatest color hues and contrast differences.

The Astaboras I canal was observed to be double. The Astusapes canal showed good contrast. Other canals easily observed were: Tartarus, Eunostos I and II, Nar, Chaos, Saus, Alcyonius, Casius, Pierius, Protonilus, Deuteronilus, Euphrates, Phison, Vexillum, and Nilosyrtis. The Nodus Laocoontis oasis was very large and green. The Nodus Alcyonius was moderately large and dark with a slight green hue. The Ismenius Lacus' Lysa and Elusa Fons were blue-black and readily observed.

**March 26, 1965**; 0517–0946 UT; CM 241°–304°; MD 19 June. The 16-inch reflector was used with a plate camera and 666×.

The North Cap was about the same physical size, with the melting regression halted and possible deposition occurring. The North Cap was still a dull gray-white and rather hard to see. The north polar hood was tenuous. The melt-band was very thin and of a low gray contrast.

Sunset clouds centered on the equator were possibly present. No atmospheric blue-clearing was detected in violet light.

The Elysium plateau was about 70% hoarfrost covered in the midafternoon at 3 o'clock. The Neith Regio appeared light with possible frost.

The gross maria features were vague in green light, being better defined in orange and red light. The Syrtis was its prominent dark blue-gray and bright blue-green hue. The Wedge-of-Casius and the Boreosyrtis were extremely dark and had high contrast in green, orange and red light, which indicates the presence of a black or a blue-black hue in this region. The Trivium was unseasonally low in contrast with a dark brown color. The Mare Cimmerium showed good black contrast in orange and red light.

The Umbra and Copais Pons were large and dark in orange and red light. The Moeris Lacus was dark and double. The Nodus Laocoontis was still large in physical size and showed moderate to strong contrast in red light, which indicates a blue or green hue. The Nodus Alcyonius was likewise very dark in red light.

The Thoth–Nepenthes canal appeared double and a moderate-contrast gray shade. The Eunostos II, Alcyonius, and Casius canals were also recorded.

**March 27, 1965**; 0351–0600 UT; CM 210°–241°; MD 19 June. The 30-inch Cassegrain used 560× and 400×.

The North Cap had once again started to recede, and showed appreciable shrinkage over the last three days. The north cap melt-band was small and appeared weak under the polar hood. Atmospheric haze was observed over the South Pole and extending along the sunset limb, across the equator, to about +45° latitude. The north polar hood was recorded to be less dense but extensive, covering +90° to +57° latitude.

Thick clouds were observed over the Amazonis desert. A violet cloud concentration and low fog or frost was seen in the Amazonis desert at coordinates 135° to 150° longitude, +40° to +25° latitude. Two cloud concentrations were over the Syrtis Major–Minor and Neith Regio. No blue-clearing was detected this evening.

The Neith Regio was covered by early morning frost. The Elysium was covered with brilliant, white, hoarfrost during the entire daylight period.

The Trivium had become a darker brown hue with oases dark gray to black concentrations and dark canal structure noted within. The Mare Cimmerium was a dark brown color. The Mare Tyrrhenum was a purple-brown, and the Syrtis a bright blue color.

The canal structure outlining the Elysium plateau was increasing in contrast to a level of good observability. The Styx canal was a dark brown color. The Thoth, Hades, Dis, Gyndes, Eleus, Laestrygon, and Phlegethon canals were a medium to dark bluish-gray hue.

**March 28, 1965**; 0556–0730 UT; CM 255°; MD 19 June. The 30-inch Cassegrain used 560×. Disk diameter 13″4.

The North Cap was clearly seen bright and white with a small accompanying haze on its preceding side. The north cap peripheral band was narrow but appeared darker than on the preceding night, because the extensive polar hood recorded since March 18 had cleared. The entire appearance of the atmospheric disk showed a decline in cloud and haze activity. A weak south polar hood was still present.

Cloud prevailed over the Amazonis desert. Early morning fog-type cloud and frost were indicated in the Aeria desert and along the Cenotria–Crocea areas. Filter cross-checking indicated a bluish haze or fog over the southern end of the Syrtis Major as well as over the Moeris Lacii. A possible weak blue-clearing of the Martian atmosphere was detected.

Hoarfrost was observed on the Libya desert, encroaching upon the Thoth canal in the Moeris Lacus position, and on the Neith Regio. Heavy frost remained on the Elysium plateau during the afternoon. The Trivium was turning an olive drab–probably the addition of green to the already present brown color. The bright blue Syrtis Major, contrasting with the early morning fog and white frost, was a beautiful phenomenon, indeed. The Wedge-of-Casius and the Boreosyrtis were also a slight olive drab hue. The Mare Tyrrhenum was still a purple and brown color.

The observed canals are listed as follows: Nilosyrtis, Rhesus, Astaboras I, Thoth, Pallas, Mosa, Aethiops, Cerberus I and II, Eunostos I and II, Hyblaeus, Chaos–Nar, Styx, Dis, Hades, Bidis, Gyndes, Alcyonius, Heliconius, Casius, and Laestrygon.

**March 29, 1965**; 0630–0756 UT; CM 228°–251°; MD 20 June. The 30-inch Cassegrain telescope employed 560×.

The North Cap had possibly increased in size; it was clear of cloud, appeared white, and possibly was irregular in outline. There was no evidence of the South Cap to date. A south polar hood extended northward on the sunset limb across the equator to about +40° latitude. Atmospheric blue-clearing observation was not successful because of local terrestrial ground haze and below-average seeing.

Much frost was noted on the Libya, Crocea, Cenotria, and Aeria deserts bordering the southern end of the Syrtis Major–the same appearance as recorded during the March 28 observation. The Elysium was a lighter shade than the surrounding ocher deserts, but did not appear a pure white–possibly afternoon melting turned the Elysium periphery a dark pink color, or there was cloud over the area. Filter cross-checking indicated a misty blue haze over the Moeris Lacii and the southern border of the Syrtis Major.

The Syrtis was a bright blue-green triangle, appearing through the white morning mist, and just before noon, changing to a darker blue-green as it cleared the light mists. The Trivium was a brown to an olive drab color. The Mare Tyrrhenum was still its purple and mottled brown coloration. The Mare Cimmerium was a dark brown with blue-gray streaks. The Mare Sirenum appeared a dark gray shade in the light of afternoon.

**March 30, 1965**; 0408–0835 UT; CM 188°–252°; MD 20 June. The 30-inch Cassegrain used 560×.

The North Cap was clear of cloud, appeared white, and irregular in shape, and a little larger in physical size. The north cap peripheral band was narrow and a weak gray shade. The south polar hood persisted to date.

An evening and morning limb haze and a bright cloud concentration confined to the Elysium region were the chief evidences of moisture in the Martian atmosphere this observing period.

The Elysium phenomena deserve special attention because clouds put on a remarkably bright display over the Elysium. Violet light indicated bright, round, high-altitude cloud peaks in the Elysium region. Blue and blue-green light indicated a less defined round border, and larger medium-altitude clouds confined to the Elysium region. Yellow-green light revealed no low-altitude sunrise fog-type cloud or haze, a sharply defined white Elysium border, and the entire Elysium region became brighter and whiter in the afternoon as the cloud structure became smaller and better defined. Photometric density measurements showed that on March 30–31 the Elysium was brighter than the North Polar Cap. An atmospheric blue clearing in the Trivium region was suspected visually but was not positively confirmed from violet photographs.

A bright evening frost patch was observed in the Arcadia desert at coordinates 110° to 125° longitude, +42° to +35° latitude. A morning frost patch was located in the Wedge-of-Casius in the Utopia region. A gray-white frost patch was noted at high noon on the Central Meridian in the Phlegra region at the coordinates 190° long., +52° lat.

A good look into the Amazonis desert was achieved, and absolutely nothing was seen crossing the huge expanse of desert. The Propontis–Euxinus–Castorius Lacii quadrangle was well developed in the Arcadia desert.

Observed canals connecting these oases were: Bidis, Midas, Athos, Fevos, and Elcus. Canals seen in the Phlegra, Zephyria, Cebrenia, and Elysium deserts were: Granicus, Gyndes, Dis, Hades, Cerberus I and II, Nar, Chaos, Hyblaeus, Alcyonius, and Heliconius. The Trivium was a brown and olive drab color.

**March 31, 1965;** 0350–0800 UT; CM 150°–235°; MD 21 June. The 30-inch Cassegrain employed 560× and 400×.

The North Cap was observed, through a weak polar haze, to be increasing in physical size. The North Cap was irregular in shape, and its peripheral band appeared darker and a little broader. A faint south polar hood was detected.

Slightly increased cloud activity was observed. An evening limb haze and an equatorial cloud band extending across the planetary disk to the morning limb haze were present. Recurrent cloud concentrations were again seen in the same position in the Arcadia desert as recorded on the preceding night. A weak, localized, atmospheric blue-clearing was suspected in the Trivium region from 150° to 240° longitude, but was not confirmed positively by photography.

Cloud and frost were still seen within the Elysium region. The Elysium was completely covered with extensive, bright, morning frost that was seen to shrink in size toward the Albor area as the region approached the noon position on the Central Meridian. The Elysium periphery formerly covered with morning frost was a dark pink color. Frost remained in the Elysium and Phlegra regions all day long.

The Mare Sirenum appeared a dark bluish-gray hue. The Cerberus II canal appeared double, all other surface features appeared the same as during the preceding night's observation.

**April 1, 1965;** 0558–0751 UT; CM 200°; MD 21 June. The 30-inch Cassegrain was employed with cameras and ocular powers of 400× to 562×.

The North Cap was somewhat irregular in outline but singular in structure and measurably larger. No arctic hood was noted. No antarctic haze was detected. The north cap melt-band was more clearly defined this evening.

The same recurrent cloud pattern over the Arcadia–Amazonis desert region was again recorded in violet and blue light. Low morning haze was located over the Laocoontis, Isidis R., and Neith R. region. The "green-haze" continued to weaken in the 130° to 240° longitudes.

The Elysium was not as white as it appeared on the previous two nights; however the frost covered the same area. Morning frost was recorded on the Neith Regio.

A good observation was made on the Phlegra–Propontis–Amazonis region, 130° to 240° longitude. The brown triangular Trivium showed good contrast in orange and yellow light, although it was still a lower contrast than on former apparitions. The Panchaia area was a dark gray. The Mare Cimmerium was a long dark feature in the south.

The Propontis I, Propontis II, Euxinus Lacus, Castorius Lacus, and Stymphalius Lacus oases were large and dark gray to green-black. The Nodus Gordii, in the south, was weakly recorded in orange light.

The Styx, Dis, Hades, and Gyndes canals were observed and recorded with ease, even though the seeing and transparency were below average.

The observing patrol was interrupted by a large frontal snow storm that blanketed the southwestern U.S. for about two weeks. Observation was once again possible on April 16.

**April 16, 1965;** 0414–0615 UT; CM 36°–66°; MD 28 June. The 30-inch Cassegrain used cameras and a power of 560×. Morning terminator width 17°. Disk diameter 13″ of arc. Axial tilt +21°.

The pure white North Cap was clear of haze, sharply defined with an irregular periphery, and about the same size as observed on April 1. The Cap had projections at coordinates 20°, +79°; and 60°, +78°; with a rift at about 45° longitude. The melt-band was a wider and darker feature with good contrast in the Baltia–Boreum region. A small antarctic hood was recorded in violet and blue light.

The Martian atmosphere was generally clear of haze, with well defined areas of cloud confined to the evening limb and morning terminator. An evening cloud or haze was located over the Eden desert at position 340°; +25° ca. A small weak cloud was evident over the Chryse desert adjacent to the Aurorae Sinus. A dense morning cloud was located over the Candor–Tharsis region just below the Martian Eye. A morning cloud was recorded in the Tempe desert area. The central part of the Martian atmospheric disk appeared somewhat transparent to violet light and moderately so to blue light. The darkest part of the Acidalium and the Niliacus Lacus–Nilokeras complex and the Aurorae Sinus were ill-defined in violet light, defining a weak blue-clearing across the Martian disk.

Frost was observed on the Argyre area. A morning frost or ice-fog area was seen in yellow-green light on the Nix Tanaica in the Tempe desert.

Many Martian summer seasonal surface changes had occurred since the last observing period on April 1. The wave-of-darkening, which is possibly a moisture wave, had affected gross maria broadening, changes in surface coloration, and canal contrast intensification across the entire visible Martian disk. Much dark feature broadening and desert darkening was recorded in green light.

The intensely black Meridiani Sinus had a sharp boundary with three canal carrot projections. The formerly dark gray Sabeaus Sinus had taken on a dark green tint. The formerly difficult-to-observe Margaritifer was now a black-green high-contrast feature with four carrot projections. The Aurorae Sinus was a blue-black feature with the Agathodaemon canal traversing the Sinus. The Capri Cornu was not a light separate entity, but was darkly filled-in. The Mare Erythraeum was a purple-brown color. The light Pyrrhae Regio showed some seasonal darkening. The Noachis seemed poorly defined as if a low haze were present. The Pandorae Fretum was a dark gray shade and easily observed. The Deucalionis Regio was a rather dark ocher hue. The greatest seasonal change had occurred in the northern hemisphere in the Acidalium longitudes. The bold Acidalium had become an intense black-green mare engulfing its internal oases and expanding into the surrounding deserts. The Acidalium was particularly broad and swollen through its central section in the neighborhood of the Novem oasis. The darkening expanded into the Tempe desert along the western border of the Acidalium and toward the south across the former light area of the Achillis Pons. The Baltia recorded extremely well in red and orange light, and poorly in green light. The Mare Boreum was a dark gray to blue-black shade.

Much darkening had transpired in the Niliacus Lacus, and three of its oases were recorded best in red light. The Niliacus oases triad were the Jordanis Fons, the Endor Fons, and the Engedii Fons. The Achillis Pons within the Nilokeras I canal was particularly dark and swollen. While at the southwestern border of the Acidalium, the Acadinius Fons was poorly recorded; thus showing a reduction in contrast. The sex-canal junction of the Lunae Lacus was also large and dark with a dark green tint. The Oxia Palus appeared a dark gray shade with an irregular pentagon canal junction shape. The dark Lysa and Elusa Fons were seen within the elongated Ismenius Lacus. The Acidalius Fons had a moderate dark gray contrast. The Arethusa Lacus was recorded by visual and photographic methods. The Clytaemnestra oasis was small and weak.

The Martian disk was a patchwork of canal structure. Canals especially affected by the seasonal darkening were the double Gehon, the double Nilokeras I and II, the singular Indus, Oxus, Deuteronilus, Callirrhoe, Tanais, Jamuna, Hydraotes, Laxartes, Uranius, and the double Ganges. Other smaller canal structures that were recorded follow: Aurum, Cantabras, Scythes (Silia), and the Chrysorrhoas. A hint of the Dardanus canal was noted.

What has been considered as a modern-day canal and referred to by the writer as the Tempes canal in the Tempe desert and parallel to the western border of the Mare Acidalium has expanded and darkened to become an obvious photographic feature. Surprisingly, green-light photographs recorded this feature best, although it was seen fairly well in orange light, and only vaguely in red light.

Green light showed all canal structures and their oases junctions as dark seasonally swollen features, with much darkening extending into the ocher deserts. The canals Gehon, Jamuna, Ganges, Nilokeras I and II, and the Uranius were especially affected in green light.

Many excellent photographs were obtained during this observing period.

**April 17, 1965**; 0430–0530 UT; CM 40°; MD 29 June. The 30-inch Cassegrain was employed with a camera and a 560× ocular.

The irregularly shaped North Cap was clear of haze and bright white with a narrow, dark peripheral melt-band. From visual and photographic measurements it was suspected that the North Cap had started its regression once again. The south polar hood had increased in size and density, connecting with evening limb haze.

Atmospheric cloud activity had increased since the last night's observation. Evening limb haze was located from the antarctic to about +40° latitude. A sunset cloud was indicated in blue light to be over the Arabia desert. An equatorial cloud band crossed the entire disk. Morning terminator haze was located over the Tempe desert from about +35° to +55° latitude. No atmospheric blue-clearing was detected in violet light.

The surface features and their heightened seasonal coloration appeared the same as observed the former night.

**April 19, 1965**; 0330–0530 UT; CM 259°–29°; MD 30 June. The 30-inch reflector was used with 562× and a camera. The axial tilt was +21°. Terminator width 28°. Disk diameter 11''.7 of arc.

The irregularly shaped North Cap was clear of haze, a bright white, and slowly decreasing in physical size with an average diameter of 22°. A beautiful, bright, and dense antarctic polar hood was recorded.

The evening limb haze was more extensive, stretching from the antarctic −90° to +50° latitude. An evening limb cloud was located over the Arabia desert. The equatorial cloud band still persisted with a width of about 20 areocentric degrees. A morning terminator cloud was seen over the Candor–Tharsis desert region. Morning haze was still located in the Tempe desert region from +30° to +45° latitude. No blue-clearing was detected.

The gross dark surface features appeared the same as observed on April 16. Because of poor quality seeing conditions, fine details and canal-like structure were not recorded.

**April 20, 1965**; 0510–0810 UT; CM 15°–59°; MD 30 June. The 30-inch reflector was employed with camera and 560×.

The North Cap was still irregular in shape and was a bright white shade, although some evening limb haze may have been present over part of the Cap. The dark gray melt-band was narrow in width but showed good contrast. The dense south polar hood was so bright that irradiation within the observer's eye made it appear to stand out from the south limb of the Martian disk.

Much cloudiness prevailed in the Martian atmosphere. An evening limb haze extended from Pole to Pole. A sunset cloud was located over the Arabia–Eden desert. A cloud band about 20 areocentric degrees wide and centered on +10° parallel bisected the planetary disk. A morning terminator haze was centered below the equator and covered the −10° to +25° latitudes just below the Coprates complex. No blue-clearing was observed.

A bright morning frost or ice-fog patch was located on the Tharsis desert at position 110° long., +10° lat.

Much dark feature broadening and desert darkening was recorded in green light. The intensely black Meridiani Sinus had a sharp boundary with three canal carrot projections. The formerly dark gray Sabaeus Sinus had taken on a dark green tint. The formerly difficult-to-observe Margaritifer was now a black-green high-contrast feature with four carrot projections. The Aurorae Sinus was a blue-black feature with the Agathodaemon canal traversing the Sinus. The Capri Cornu was not a light separate entity, but was darkly filled-in. The Mare Erythraeum was a purple-brown color. The light Pyrrhae

Regio showed some seasonal darkening. The Noachis seemed poorly defined as if a low haze was present. The Pandorae Fretum was a dark gray shade and easily observed. The Deucalionis Regio was a rather dark ocher hue. The greatest seasonal change had occurred in the northern hemisphere in the Acidalium longitudes. The bold Acidalium had become an intense black-green mare engulfing its internal oases and expanding into the surrounding deserts. The Acidalium was particularly broad and swollen through its central section in the neighborhood of the Novem oasis. The darkening expanded into the Tempe desert along the western border of the Acidalium and toward the south across the former light area of the Achillis Pons. The Baltia recorded extremely well in red and orange light, and poorly in green light. The Mare Boreum was a dark gray to blue-black shade.

Much darkening had transpired in the Niliacus Lacus, and three of its oases were recorded best in red light. The Niliacus oases triad were the Jordanis Fons, the Endor Fons, and the Engedii Fons. The Achillis Pons within the Nilokeras I canal was particularly dark and swollen. While at the southwestern border of the Acidalium, the Acadinius Fons was poorly recorded; thus showing a reduction in contrast. The six-canal junction of the Lunae Lacus was also large and dark with a dark green tint. The Oxia Palus appeared a dark gray shade with an irregular pentagon canal junction shape. The dark Lysa and Elusa Fons were seen within the elongated Ismenius Lacus. The Acidalius Fons had a moderate dark gray contrast. The Arethusa Lacus was recorded by visual and photographic methods. The Clytaemnestra oasis was small and weak.

The Martian disk was a patchwork of canal structure. Canals especially affected by the seasonal darkening were the double Gehon, the double Nilokeras I and II, the singular Indus, Oxus, Deuteronilus, Callirrhoe, Tanais, Jamuna, Hydraotes, Laxartes, Uranius, and the double Ganges. Other smaller canal structures that were recorded follow: Aurum, Cantabras, Scythes (Silia), and the Chrysorrhoas. A hint of the Dardanus canal was noted.

The new Tempes canal was large and moderately dark gray; recording best in yellow-green light, although orange and red light photographed the feature clearly. The Nix Tanaica retained its normal ocher appearance.

Green light showed all canal structures and their oases junctions as dark seasonally swollen features, with much darkening extending into the ocher deserts. The canals Gehon, Jamuna, Ganges, Nilokeras I and II, and the Uranius were especially affected in green light.

Many excellent photographs were obtained this observing period.

**April 21, 1965**; 0410–0520 UT; CM 0°; MD 1 July. The 30-inch Cassegrain was used with a 560× ocular and cameras.

The shrinking irregular North Cap appeared white with a weak evening limb haze over the preceding side. The melt-band was sharp and narrow, but it contrasted well with the white Cap. The south polar hood appeared bright and dense.

An evening limb haze was still in evidence, and it extended from Pole to Pole. A sunset cloud was located over the Arabia desert. A cloud band of about 20 areocentric degrees wide and roughly centered on the +10° parallel spanned the entire visible disk. A morning terminator cloud or ice-fog was located over the Candor desert at 70° long.; +10° lat. ca. The observational test for atmospheric blue-clearing was not possible because of the decreasing terrestrial sky transparency.

The Syrtis Major and the Sabaeus Sinus in the south, and the Mare Acidalium were recorded in red light only between snow squalls before the observing period was clouded out by the increasing snow storm.

**April 23, 1965**; 0458–0556 UT; CM 350°; MD 2 July. The 30-inch Cassegrain instrument was used with 350× and 560× oculars and cameras. The axial tilt was +22°. The terminator width was 30°. Disk diameter 11″ of arc.

The North Cap appeared slightly larger with a possible new night frost deposit. The cap was a dull white. The irregularity of the Cap's periphery was gone and the dark rift was apparently covered by the new deposition because the Cap was a smooth circular compass. An arctic polar hood was eccentrically positioned toward the evening limb. The north cap melt-band was barely perceptible; possibly it was covered by ice-fog or frost from the new deposition. The regression of the North Cap had certainly been slow and erratic ever since mid-Martian June. The antarctic hood was easily seen in blue and violet light. The Hellas plateau shone brightly through the antarctic haze and projected beyond the preceding edge of the visible disk, giving the planet a distorted appearance in the south. The Hellas whitening appeared brightest and sharpest in yellow-green and blue-green light relative to violet and blue light, and it was also clearly recorded in red light; which indicated a low-level ice-fog type cloud and/or surface frost. The Hellas was brighter than the North Cap.

A small evening cloud persisted over the Isidis–Neith Regio at position 275° long., +25° lat. A weak morning haze was located over the Candor–Tempe desert from 0° to +32° lat. A weak evening limb haze extended from Pole to Pole. No blue-clearing was detected in violet light.

The Syrtis Major was changing its color from a bright blue to a darker blue hue. The Sabaeus Sinus was its usual dark gray shade. The Meridiani Sinus was still an intense black. The Casius, Umbra, and Copais in the Boreosyrtis showed some loss in contrast, but they were still a dark blue-gray hue. The bold Mare Acidalium still retained its dark gray and gray-green appearance.

**April 24, 1965;** 0440–0730 UT; CM 331°–10°; MD 2 July. The 30-inch and 16-inch reflectors were employed with cameras and 560×.

The North Polar Cap appeared larger than on April 21, and it was circular in outline and white in shade. No dark rift was seen within the Cap. Arctic haze still persisted over the Cap. The melt-band was poorly seen and apparently still covered with new frost deposition. The Antarctic appeared white with its polar hood and with possible white frost patches beneath.

Evening cloud and haze persisted in the Isidis–Neith Regio at position 275° long., +25° lat. A weak sunset limb haze extended from Pole to Pole. No blue-clearing was detected in violet light.

The Hellas plateau was still covered by a bright blanket of frost and/or ice-fog that was best recorded in yellow-green and red light. The bright white Hellas contrasted beautifully with the dark blue Syrtis Major. Densitometer measurements showed the Hellas to be brighter than the North Cap.

The Syrtis Major was changing its color from a bright blue to a darker blue hue. The Sabaeus Sinus was its usual dark gray shade. The Meridiani Sinus was still an intense black. The Casius, Umbra, and Copais in the Boreosyrtis showed some loss in contrast, but they were still a dark blue-gray hue. The bold Mare Acidalium still retained its dark gray and gray-green appearance.

**April 27, 1965;** 0430–0558 UT; CM 300°; MD 4 July. The 30-inch Cassegrain reflector employed 500×. The planetary disk diameter was 10″.9. Axial tilt toward Earth was 22°.

The North Cap appeared about the same size as when observed on April 24th. The North Cap rate-of-change was still halted. The south polar hood was weaker.

Evening limb haze extended over the North Cap. The bright Hellas was partially covered on the evening side by limb haze. The Hellas frost blanket extended into the south polar region, and appeared to be brighter than the North Cap. Much cloud was noted on the morning and evening limb centered on the equator. Evening limb haze extended from pole to pole, and covered the Elysium region. Clouds were over the Elysium and the Eden areas. No atmospheric blue-clearing was detected.

Much frost existed on the Martian disk. Heavily frosted areas were the Aeria desert, Neith–Isidis Regio, and the Elysium plateau.

The blue Syrtis Major appeared to have a slight green tint. The Mare Tyrrhenum and Iapygia were still a dark purple and mottled brown.

The Thoth–Nepenthes canal was definitely double with a dark gray-blue hue. The Casius was broad and a dark gray-blue color. The Alcyonius had a dark gray-blue hue. Equatorial and southern canals were beginning to be affected by the northern darkening wave. Canals showing seasonal darkening were the Amenthes, Nilosyrtis, Astusapes, Astaboras I, and Arosis.

The Umbra and Copais, swollen oases, were both dark gray-blue and gray-green colors. The Nodus Laocoontis oasis was a large dark green object. The Moeris Lacus was double and a black-green color.

**April 28, 1965;** 0438–0602 UT; CM 294°–314°; MD 4 July. The 30-inch Cassegrain employed 560× ocular.

No size or change appeared in the North Cap from the last night's observation. The evening limb haze extended over the North Cap. The bright Hellas was partially covered on the evening side by limb haze. The Hellas frost blanket extended into the south polar region, and appeared to be brighter than the North Cap.

Much cloud was noted on the morning and evening limb centered on the equator. Evening limb haze extended from Pole to Pole, and covered the Elysium region. No atmospheric blue-clearing was detected.

Much frost existed on the Martian disk. Heavily frosted areas were: the Aeria desert, Neith–Isidis Regio, and the Elysium plateau.

The blue Syrtis Major appeared to have a slight green tint. The Mare Tyrrhenum region was still a dark purple and mottled brown. The broad double Thoth canal was a dark gray-blue. The Umbra and Copais, swollen oases, were both dark gray-blue and gray-green colors. The Nodus Laocoontis oasis was a large dark green object.

**April 29, 1965;** 0655–0822 UT; CM 318°–337°; MD 4–5 July. The 30-inch Cassegrain used 560× and camera.

The North Cap appeared irregular once again and larger on first inspection, but probably had remained a constant size for the past seven or eight days. The North Cap was possibly covered with a weak haze, although its south edge was as bright as the Hellas plateau. A gray-white area was seen just off the north cap periphery at coordinates 0° to 25° longitude, in the Cydonia desert. The south polar hood was still in evidence although observation was difficult because of the proximity of the very bright Hellas plateau.

A weak evening haze was seen over the Elysium region. Evening clouds were still located over the Isidis–Neith Regio. A general haze-clear appearance of the Martian atmosphere was noted. The dark Syrtis Major was observed fairly well in blue light, but no identification of it could be made in violet light; therefore, no confirmation of a blue-clearing was made.

A weak frost or fog cloud was observed over the Oxia on the sunrise terminator. Heavy frost patches denoted the presence of much atmospheric moisture. Frosted areas are listed as follows: Hellas, Isidis Regio, Neith Regio, and the Nymphaeum in the Aeria desert.

The blue-green Syrtis was showing more green coloration. The Sabaeus Sinus was a darker gray to black shade, and the Pandorae Fretum was darker brown. The southern maria were showing seasonal greening and darkening.

The Wedge-of-Casius and Thoth canal were filling in and increasing their contrast. Other observed canals were the Alcyonius, Protonilus, Pierius, Nilosyrtis, Astaboras I and II, Astusapes, Phison–Vexillum, Euphrates, Gehon, Typhon, Eunostos II, Adamas, and Amenthes.

**April 30, 1965;** 0645–0807 UT; CM 306°–326°; MD 5 July. The 30-inch Cassegrain used 560×.

The North Cap appeared only slightly smaller than the large southern white area covering the Hellas and south polar regions in blue light (W-38), indicating a north polar hood. The North Cap area appeared smaller in violet light (W-47). The North Cap was small and well defined in yellow-green light (W-57), which showed the physical dimensions of the Cap to be approximately the same as observed on the past three to four nights. The North Cap was not as bright and white as the Hellas frosted plateau; only the south edge of the North Cap shone as brightly as the Hellas. The North Cap was seen with difficulty in orange light (W-23 and -106), whereas the Hellas plateau was clearly seen. Blue-green light (W-64) also indicated a north polar hood. The melt-band was thin and low in contrast and difficult to define. The brilliant, white Hellas region blended into the south polar region. The southern region possibly had some haze cover. The South Pole was tilted 22° away from the observer, so that the southern limb presented the −60° latitude to the observer.

The Elysium region showed partial evening frost. Clouds were evident over the Elysium and Zephyria deserts. A possible atmospheric blue-clearing was detected in violet light (W-47) confined to the periphery of the antarctic region. The Syrtis and southern maria were clearly noted in blue light. Evening and morning hazes were seen in latitudes +22° to −10°. One cloud was located over the Neith Regio at 270° long., +35° lat. ca.

The Casius, Umbra, and Copais areas were becoming a dark gray-green hue. The Syrtis was a definite blue-green. The Sabaeus was a dark gray to black shade. The Pandorae Fretum was showing good contrast and was a dark brown color. The Mare Tyrrhenum was still a purple and brown.

The Nilosyrtis canal was narrow but a darker shade. The Phison–Vexillum, Arosis, Astusapes, Astaboras I and II, Typhon, Protonilus, Deuteronilus, Pierius, and Alcyonius canals were readily seen. The Nepenthes–Thoth canal was a double, broad, dark, and gray-blue feature. The Moeris Lacii were multiple, large, and black-green. The Nodus Laocoontis covered a large area in the Aethiopis desert, of a medium contrast, and the greenest colored surface feature on the Martian disk. The Ismenius Lacus was a prominent dark feature with its Lysa Fons and Elusa Fons a black shade.

**May 1, 1965**; 0520–0617 UT; CM 276°–285°; MD 5 July. The 30-inch Cassegrain reflector employed 560×.

The North Cap appeared large and about as wide as the southern white area covering the Hellas and south polar regions in blue light (W-38), indicating the presence of a north polar hood. The North Cap area appeared smaller in violet light (W-47). The North Cap was small and well defined in yellow-green light (W-57), which showed the physical dimensions of the Cap to be approximately 22° in width and the same size as observed on the past three to four nights. The North Cap was not as bright and white as the Hellas frosted plateau; only the south edge of the Cap shone as brightly as the Hellas. The North Cap was seen with difficulty in orange light (W-23 and -106), whereas the Hellas plateau was clearly and brightly seen. Blue-green light (W-64) also indicated a north polar hood. The brilliant, white Hellas region blended into the south polar region. Cloud and haze determination in the antarctic was not possible because of the proximity of the bright Hellas plateau combined with the planetary axial tilt of +22°.

The Elysium region had some evening frost, while clouds were evident over the Elysium and Zephyria deserts. A possible atmospheric blue-clearing was again detected in violet light (W-47) confined to the southernmost visible latitudes. A morning haze was confined to the Eden desert at latitudes −2° to +30°. The morning haze had decreased in density by this observation. A cloud was located over the Elysium region.

The Casius, Umbra, and Copais areas were a dark gray-green hue. The Syrtis was a definite blue-green. The Sabaeus was a dark gray to black shade. The Pandorae Fretum was showing good contrast and was a dark brown color. The Mare Tyrrhenum–Iapygia was still a purple and brown. The Nilosyrtis was narrow and a darker shade. The Phison–Vexillum, Arosis, Astusapes, Astaboras I and II, Typhon, Protonilus, Deuteronilus, Pierius, and Alcyonius were readily seen. The double Nepenthes–Thoth canal was a broad dark, gray-blue feature. The Moeris Lacii were large and black-green. The Nodus Laocoontis covered a large area in the Aethiopis desert and was of a medium contrast and the most green saturated surface feature on the Martian disk. The Ismenius Lacus was a prominent dark feature with its Lysa Fons and Elusa Fons a black shade.

**May 2, 1965**; 0555–0653 UT; CM 284°; MD 6 July. The 30-inch Cassegrain used a 560× ocular and cameras.

The physical size of the North Cap had shown little apparent change. The North Cap had regained a more normal circular appearance, indicating possible nightly frost deposition. A south polar hood was suspected over the Hellas because it was not as bright as it had been observed on April 29 through May 1. The Hellas region was not as bright as the North Cap although it was much larger in area.

A small area of evening limb cloud was seen over the Trivium–Elysium region. A sunrise terminator haze was observed in the Arabia–Eden desert. No atmospheric blue-clearing was detected this night.

Because of bad astronomical seeing, only the large, dark Syrtis Major could vaguely be seen on the surface.

**May 6, 1965**; 0545–0725 UT; CM 236°–259°; MD 8 July. The 30-inch Cassegrain used 560× and cameras.

The North Cap still appeared about the same circular, physical size with little appreciable shrinkage. It is quite possible that the Cap had been undergoing nightly deposition in order to retain its physical size during the Martian seasonal date of July 8th. No north polar cloud or haze was seen. The melt-band was thin and low in contrast and difficult to define as a separate entity.

No positive sunrise terminator cloud identification was made. Evening cloud was over the Trivium–Elysium region. An equatorial cloud band was present across the disk. No blue-clearing was detected in the Martian atmosphere.

Only the gross dark surface features were observed. No colorimetry was possible because of poor seeing and wind on the instrument.

**May 7, 1965**; 0735–0806 UT; CM 254°–261°; MD 8 July. The 30-inch Cassegrain reflector was used and employed 560×.

The North Cap still appeared about the same circular, physical size with some apparent shrinkage. A weak evening north polar cloud or haze was seen.

A weak morning haze was observed on the terminator over the Aeria desert. Evening cloud was over the Trivium–Elysium region. An equatorial cloud band was observed in blue light. No blue-clearing was detected in the Martian atmosphere.

Only the gross dark surface features were observed. No colorimetry was possible because of poor seeing and wind.

**May 9, 1965**; 0422–0503 UT; CM 190°; MD 9 July. The 16-inch reflector was used with 400× and a camera.

The North Cap appeared to be physically static. Weak haze was noted in blue light on the evening limb of the arctic region. The melt-band was barely discernible.

Haze was present on the evening limb over the Tharsis–Arcadia desert. No recurrent clouds were observed over the Arcadia–Amazonis deserts. Diminishing evidence of "green-haze" opacity was detected in the longitudes 120° to 190° because the dark surface detail was well recorded in yellow-green light.

The southern Maria Sirenum and Cimmerium were dark gray shades with gray-blue hues. The Panchaia region appeared a dark gray. The Propontis complex was the darkest northern hemisphere feature. The Trivium was still low in contrast, about 30% below the average contrast figure observed the past seven apparitions.

The Hades, Styx, and Dis canals were vaguely recorded.

**May 10, 1965**; 0502–0800 UT; CM 200°; MD 10 July. The 16-inch instrument was employed with a plate camera and a 400× ocular. The axial tilt was +23°. Terminator width 35°. Disk diameter 9″.8 of arc.

The North Cap appeared to be physically static. Weak haze was noted in blue light on the evening limb of the arctic region. The melt-band was barely discernible.

Haze was present on the evening limb over the Tharsis–Arcadia desert. No recurrent clouds were observed over the Arcadia–Amazonis deserts. Little evidence of the "green-haze" opacity was detected in the longitudes 120° to 190° because the dark surface detail was recorded in yellow-green light.

The southern Maria Sirenum and Cimmerium were dark gray shades with gray-blue hues. The Panchaia region appeared a dark gray. The Propontis complex was the darkest northern hemisphere feature. The Trivium was still low in contrast, about 30% below the average contrast figure observed the past seven apparitions.

The Hades, Styx, Dis, and Gyndes canals were vaguely recorded.

**May 16, 1965**; 0540–0547 UT; CM 142°; MD 13 July. The 16-inch Cassegrain employed a plate camera and a 666× ocular.

The 21°-wide North Cap was clear and bright white. No peripheral melt-band was noted. A weak antarctic hood was visually seen.

A small sunset cloud was noted over the Candor–Tharsis desert region just below the Martian Eye of the Thaumasia. No blue-clearing was detected in violet light. The Martian atmosphere still shows some opacity toward yellow-green light defining a weak "green-haze" in the 80° to 200° longitudes.

Nothing was recorded in the great deserts of the Tempe, Arcadia, and Amazonis in yellow-green light. The seasonally dark oasis complex, the Propontis, was recorded in yellow-green light. The Panchaia still showed good contrast.

**May 17, 1965**; 0335–0645 UT; CM 102°–146°; MD 13 July. The 16-inch Cassegrain telescope using 666× was employed.

The North Cap was bright, clear of clouds, and definitely slightly smaller in size. The North Cap was apparently decreasing slowly in size. An irregular white area was observed in blue light over the South Pole, probably a polar cloud hood.

Blue light indicated morning clouds over the Amazonis, Trivium, and Elysium regions. Two evening clouds were over the Oxia–Chryse deserts and the Thaumasia desert. No blue-clearing was observed on the disk.

Only the dark Hades canal and Propontis–Euxinus oases were seen on the Amazonis border. No other surface markings were seen in the Amazonis, Arcadia, and Tharsis deserts. The Mare Acidalium and Nilokeras canals were vaguely seen.

**May 20, 1965**; 0332–0415 UT; CM 80°; MD 14 July. The 16-inch telescope was used with a plate camera and 666×.

The North Cap was steadily but slowly melting, and it appeared sharp and clear of haze and bright white. The melt-band was not seen as a separate entity.

An evening limb cloud was positioned over the Chryse desert near the equator. A weak morning terminator haze was located in the northern hemisphere over the Amazonis–Propontis region. The atmosphere was opaque to violet light.

The Mare Acidalium was still an extremely dark contrast and gray-green feature.

**May 28, 1965;** 0416–0545 UT; CM 09°; MD 18 July. The 30-inch and 16-inch Cassegrain telescopes employed cameras and 200×, 400× and 666× oculars. Axial tilt +23°. Terminator width 38°. Disk diameter 8.″6 of arc.

The slowly melting North Cap was clear and sharp and bright white. No peripheral melt-band was noted.

A weak evening limb haze was present in blue-green light over the Aeria–Arabia desert. No blue-clearing was detected.

The southern maria were a dark gray to black-blue shade. The Mare Acidalium was a dark gray-green hue.

No canal structure was recorded.

**May 30, 1965;** 0615–0638 UT; CM 18°; MD 19 July. The 16-inch reflector employed 666× and 1000×.

The North Cap was smaller and dull white. Blue light indicated a morning limb haze over the arctic region. The North Cap was observed best in yellow light. The melt-band was not seen at the north cap periphery. A small south polar hood was observed in the antarctic.

A sunset cloud was seen over the Aeria desert. Morning clouds and blue haze were located over the Candor–Tharsis deserts just below the Martian Eye. A morning terminator haze extended from 0° to +90° latitude. The Martian atmosphere remained opaque to violet light.

The Sabaeus Sinus was a black to a dark gray shade. The Meridiani Sinus was an intense black. The Margaritifer Sinus was a dark gray to dark brown color. The Mare Acidalium was a dark gray-green color with one internal canal streak located near the north border. The Baltia was a black-blue high-contrast feature.

The Niliacus had lost much of its dark contrast and color. Most of the small dark oases concentrations had disappeared from the Acidalium–Niliacus region. The Acadinius–Achillis Fons remained extremely dark and was a mono-oasis. The Acidalia Fons retained good black-green contrast. The Jordanis Fons was fading.

The Gehon I and II canals were recorded connecting the Lex Fons, of the Meridiani S., to the Jordanis Fons, of the M. Acidalium. The Indus and Oxus canals exhibited good contrast; consequently, they were easily recorded. The Callirrhoe canal connected with the weak Novem Fons and was seen to continue across the Acidalium to the Acidalius Fons. The Jamuna canal was partly observed extending from the Niliacus Lacus, a little way out into the Chryse desert, and becoming lost to view. The Tanais canal also held a good dark gray contrast.

**May 31, 1965;** 0357–0422 UT; CM 340°; MD 20 July. The 16-inch telescope was used visually with 400× and 1000× oculars.

The North Cap was small and a dull white. Blue light indicated a morning limb haze over the arctic region. The North Cap was observed best in yellow light. The melt-band was not observed to be present at the north cap periphery. A small south polar hood was observed in the antarctic.

A sunset cloud was seen over the Aeria desert. Morning clouds and blue haze were located over the Candor–Tharsis deserts just below the Martian Eye. A morning terminator haze extended from 0° to +90° latitude. The Martian atmosphere remained opaque to violet light.

The Sabaeus Sinus was a black to a dark gray shade. The Meridiani Sinus was an intense black. The Margaritifer Sinus was a dark gray to dark brown color. The Mare Acidalium was a dark gray-green color with one internal canal streak located near the north border. The Baltia was a black-blue high-contrast feature.

The Niliacus had lost much of its dark contrast and color. Most of the small dark oases concentrations had disappeared from the Acidalium–Niliacus region. The Acadinius–Achillis Fons remained extremely dark and was a mono-oasis. The Acidalia Fons retained good black-green contrast. The Jordanis Fons was fading.

The Gehon I and II canals were recorded connecting the Lex Fons, of the Meridiani S., to the Jordanis Fons, of the Acidalium M. The Indus and Oxus canals exhibited good contrast; consequently, they were easily recorded. The Callirrhoe canal connected with the weak Novem Fons and was seen to continue on across the Acidalium to the Acidalius Fons. The Jamuna canal was partly observed extending from the Niliacus Lacus, a little way out into the Chryse desert, and becoming lost to view. The Tanais canal also held a good dark gray contrast.

**June 1, 1965;** 0400–0436 UT; CM 325°; MD 20 July. The 16-inch Cassegrain was used visually with 400× and with cameras.

The North Cap was not as bright as observed on May 31. The arctic region was shrouded in haze, but the ice cap could be faintly seen through the haze. Antarctic haze detection was not possible because of the overpowering brilliancy of the white Hellas plateau.

The violet and blue disk was uniformly opaque and showed no blue-white cloud areas. The atmosphere showed a general clearing trend. No blue-clearing was detected in violet light.

Possible antarctic frost blended into the brilliant frost-covered Hellas plateau, which contrasted strongly with the dark blue-green Syrtis Major. The white Hellas was seen best in yellow-green (W-57) light, although blue (W-38) light indicated a weak cloud cover over part of it. A diurnal frost region was noted across the northern tip of Mare Syrtis covering half of Isidis–Neith Regio. The Aeria desert was partially frost white in the Nymphaeum area. The Nix Cydonia on the eastern border of the Acidalium was also white. The Noachis had a possible thin white frost cover.

The Syrtis Major was still a blue-green color. The Maria Tyrrhenum and Iapygia were a purple-brown hue. The Boreosyrtis and Utopia region was a black-blue and dark gray-green color. The Sabaeus Sinus was a normal dark gray to black shade. The Noachis area was a light ocher hue. The Acidalium was a dark gray-green color. No color hue could be ascertained in the Nodus Laocoontis area.

The Thoth–Nepenthes, Nilosyrtis, Protonilus, Deuteronilus, Astaboras I, Astaboras II, Vexillum–Phison, and Astusapes canals all displayed a good dark gray-blue contrast. Apparently the gross dark features as well as the fine surface structures in the northern hemisphere were at maximum seasonal contrast and coloration.

**June 2, 1965;** 0325–0400 UT; CM 310°; MD 21 July. The 16-inch reflector employed 400× and planetary cameras. The axial tilt was +24°. The terminator width 38°. The disk diameter was 8″.4 of subtended arc.

The North Polar Cap was clearly seen free of haze and it appeared larger or rejuvenated with possible new deposition. On its south periphery at approximately 310° to 312° of longitude a bright shiny spot was in evidence.

Blue and blue-green light indicated evening haze over the limb sector of the Libya desert, Isidis Regio, and Neith Regio. A possible weak blue-clearing was noted in visual violet (W-47B) light, but it could not be absolutely confirmed on the violet and blue photographic images.

Antarctic frost blended into the brilliant frost covered Hellas area which contrasted strongly with the dark blue-green Syrtis Major. A large, bright, high-noon frost area was again noted covering half of the Isidis Regio and Neith Regio; and further, extending across the Nilosyrtis canal into the Meroe Insulae area. This frost area was best noted in yellow-green light.

The Syrtis Major was still a blue-green color. The Maria Tyrrhenum and Iapygia were a purple brown hue. The Boreosyrtis and Utopia region was a black-blue and dark gray-green color. The Sabaeus Sinus was a normal dark gray to black shade. The Noachis area was a light ocher hue. The Acidalium was a dark gray-green color. No color hue could be ascertained in the Nodus Laocoontis area.

The Thoth–Nepenthes, Nilosyrtis, Protonilus, Deuteronilus, Astaboras I, Astaboras II, Vexillum–Phison, and Astusapes canals all displayed a good dark gray-blue contrast. Apparently the gross dark features as well as the fine surface structures in the northern hemisphere were at maximum seasonal contrast and coloration.

**June 5, 1965;** 0355–0623 UT; CM 287°–316°; MD 22 July. The 16-inch Cassegrain employed 400× and planetary cameras.

No physical change could be detected in the North Cap. No dark peripheral melt-band had been observed for days. The antarctic frost in the Ausonia, Hellas, and Noachis combined to make a brighter pole than the North Polar Cap.

The Syrtis Major was still a blue-green color. The Maria Tyrrhenum and Iapygia were a purple brown hue. The Boreosyrtis and Utopia region was a black-blue and dark gray-green color. The Sabaeus Sinus was a normal dark gray to black shade. The Noachis area was a light ocher hue. The Acidalium was a dark gray-green color.

No color hue could be ascertained in the Nodus Laocoontis area.

The Thoth–Nepenthes, Nilosyrtis, Protonilus, Deuteronilus, Astaboras I, Astaboras II, Vexillum–Phison, and Astusapes canals all displayed a good dark gray-blue contrast. The gross dark features as well as the fine surface structures in the northern hemisphere were at maximum seasonal contrast and coloration.

**June 6, 1965**; 0445–0510 UT; CM 290°; MD 23 July. The 16-inch telescope used 400× and planetary cameras.

The North Cap still appeared the same physical size as recorded since June 2 TD. The antarctic frost covered areas were not as bright as on June 5 TD, but were of equal brightness with the North Cap.

Sunset clouds were evident over the Elysium and Aethiopis areas. A possible weak blue-clearing was noted in visual violet light, but it could not be confirmed on the violet and blue photographic images.

Frost was poorly observed on the Isidis Regio.

Little surface detail was seen due to poor seeing scintillation conditions.

**June 7, 1965**; 0458–0508 UT; CM 282°; MD 23 July. The 16-inch reflector was again used with 320× and 400× oculars.

The North Cap still appeared the same physical size as recorded since June 2 TD.

The sunset clouds were evident over the Elysium and Aethiopis areas. A possible weak blue-clearing was noted in visual violet light, but it could not be confirmed on the violet and blue photographic images.

Frost was poorly observed on the Isidis Regio.

Little surface detail was seen due to poor seeing scintillation conditions.

**June 9, 1965**; 0505–0526 UT; CM 270°; MD 24 July. The 16-inch Cassegrain employed 400×.

The North Polar Cap was possibly smaller than it appeared during the last several observation periods. It was slightly brighter than the white Hellas in the south. There was a possible weak antarctic haze.

No atmospheric blue-clearing was detected in violet light. The violet-blue atmospheric disk was uniform in opacity and level of brightness, showing no definite cloud concentrations.

White frost was seen on the Elysium plateau in yellow-green and orange light, and not seen in blue or violet light.

The Syrtis Major was still a dark blue-green hue. The broad Thoth canal was a medium dark gray shade. No finer surface detail could be seen because of poor seeing, wind on the telescope, and drifting cumulus clouds.

**June 10, 1965**; 0415–0507 UT; CM 250°; MD 25 July. The 16-inch reflector employed 400× and planetary cameras.

The North Cap appeared the same small size and free of cloud or haze. The North Cap measured about 20° in diameter. The Cap was brighter than the Hellas. The northern melt-band was absent. There was a possible haze present in the antarctic. No frost whitening was observed in the antarctic.

No atmospheric blue-clearing was detected in violet light. A rather weak morning haze was seen near the equator in 0° to +20° latitude.

The Hellas plateau was bright white with frost. The Elysium was partly light ocher and gray-white. The white covered area of the Elysium was observed to form toward evening.

The Syrtis was a darkening blue-green color. The Trivium was still below normal seasonal contrast, exhibiting a medium brown color.

The dark gray Thoth canal was very broad and filled in between the double canal system. The Nilosyrtis, Astaboras I and II, and Astusapes were a dark gray.

**June 11, 1965**; 0359–0425 UT; CM 232°; MD 25 July. The 16-inch Cassegrain instrument employed 400× and planetary cameras. The axial tilt was +24°5. The terminator width was 39°5. Disk diameter 7″8 of arc.

The North Cap appeared the same small size and free of cloud or haze. The North Cap measured about 20° in diameter. The Cap was brighter than the Hellas. The northern melt-band was absent. There was a possible haze present in the antarctic. No frost whitening was observed in the antarctic.

No atmospheric blue-clearing was detected in violet light.

The Hellas plateau was bright white with frost. The Elysium was partly light ocher and gray-white. The white-covered area of the Elysium was observed to form toward evening.

The Syrtis was a darkening blue-green color. The Trivium was still below normal seasonal contrast, exhibiting a medium brown color.

**June 12, 1965**; 0500–0522 UT; CM 234°; MD 26 July. The 16-inch reflector employed 400×.

The small North Cap was shrinking rather slowly. The Cap was bright white and free of clouds. The peripheral melt-band was still absent.

No atmospheric blue-clearing was detected in violet light. A sunset cloud was present over the Electris area at approximately −45° latitude.

No frost areas were observed.

The southern maria were occasionally seen in the poor astronomical seeing. No colorimetry was possible. No canals were observed.

**June 13, 1965**; 0458–0520 UT; CM 230°; MD 26 July. The 16-inch reflector employed 400× and a camera.

The small, white North Cap was smaller and well defined at times.

No atmospheric blue-clearing was evident in violet light. A sunset cloud was present in the southern hemisphere from +10° to −50° latitude.

The Trivium was vaguely seen in the poor seeing and sky transparency conditions.

**June 15, 1965**; 0340–0450 UT; CM 195°; MD 27 July. The 30-inch USGS Cassegrain instrument was employed with 560× and planetary cameras.

The small, white North Cap continued to slowly melt back. No peripheral melt-band was observed. There was no evidence of antarctic haze.

A large evening cloud was centered near the equator over the Tharsis–Amazonis desert at 130° long., +10° lat. ca. A morning terminator haze was located over the Aethiopis, Libya, and Isidis Regio areas at 263° long., +8° lat. ca. No blue-clearing was observed.

The Elysium plateau was a weak white shade in the morning sunlight.

The southern maria appeared dark; however, no color could be defined. In the north, the Trivium Charontis and Hades canal were a dark brown color. The Propontis complex was a dark gray to black shade. The Scandia and Panchaia areas still held a strong dark seasonal contrast.

No surface detail was observed in the Arcadia–Amazonis desert region.

**June 17, 1965**; 0355–0447 UT; CM 176°; MD 28 July. The 30-inch Cassegrain telescope employed 560× and planetary cameras. Axial tilt +24°5. Terminator width was 29°5. The disk diameter was only 7″5 of arc.

No physical change was noted in the small North Cap. The peripheral melt-band had apparently disappeared for the Martian season.

A large sunset limb recurrent cloud was located near the equator over the Tharsis desert just north of the Martian Eye. The atmosphere appeared generally hazy. No blue-clearing was detected in violet light. No "green haze" was evident in yellow-green light in the 110° to 200° longitudes.

The northern and southern maria were vaguely seen due to poor astronomical seeing.

**June 18, 1965**; 0324–0414 UT; CM 160°; MD 29 July. The 30-inch Cassegrain employed 560× and cameras.

The small North Cap was bright and clear of haze. Nothing was seen in the antarctic region.

The entire atmospheric disk of Mars appeared hazy in blue light. A low-altitude evening fog was recorded over the Tharsis–Arcadia desert region at the coordinates 90° to 115° long.; −10° to +30° lat. A violet-light recurrent cloud concentration was located at 90° to 110° long.; 0° to −15° lat. No atmospheric blue-clearing was observed on the violet disk of Mars.

A white morning frost was located on the terminator on the Elysium plateau.

No surface detail was observed in the vast Arcadia–Amazonis desert region. The Scandia and Panchaia appeared a dark contrast, gray shade. The Trivium Charontis was a weak, medium-contrast brown hue. The Propontis complex still held its seasonal dark gray contrast. The southern maria were vaguely observed.

Only the relatively dark and broad Hades and Dis canals were easily recorded.

**June 19, 1965**; 0430–0530 UT; CM 168°; MD 29 July. The 30-inch reflector was employed using 560× and planetary cameras.

The North Cap was seen bright white with little shrinkage. No haze was detected in the Martian arctic or antarctic regions.

The same recurrent evening cloud was observed over the Tharsis desert. No atmospheric blue-clearing was detected. No "green haze" was seen in the Arcadia–Amazonis deserts.

The Elysium plateau did not appear white.

Poor astronomical seeing prevented quality surface-detail data.

**June 20, 1965**; 0420–0455 UT; CM 150°; MD 30 July. The 30-inch reflector used 560× and planetary cameras.

The North Cap was haze-free, small, white, sharply defined, and slowly melting back toward the Pole.

A large sunset limb recurrent cloud was observed over the Candor–Tharsis desert at position 90° long., +08° lat. The atmosphere appeared completely opaque to violet light, indicating no blue-clearing.

The Elysium remained within the morning terminator shadow; therefore, the usual early morning frost was not seen in this latitude.

The gross dark surface features were vague. Except for the dark gray Propontis complex in the north, the great Arcadia–Amazonis desert region was featureless.

The astronomical seeing was poor.

**June 21, 1965**; 0500–0530 UT; CM 150°; MD 30 July. The 30-inch Cassegrain employed 560× and cameras.

The small, white, neat compass of the North Cap was clear of arctic haze. No peripheral melt-band was noted. The same afternoon recurrent cloud formation was again seen over the Tharsis–Candor deserts and extended south over the Martian Eye in the Thaumasia area. No morning terminator haze was present. No atmospheric blue-clearing was detected in violet light.

No surface markings were observed crossing the Arcadia–Amazonis desert region. To the north, the dark contrast continued through the Scandia area to the North Cap.

The astronomical seeing was below average.

**June 23, 1965**; 0355–0510 UT; CM 114°–131°; MD 31 July. The 30-inch Cassegrain used 560× and planetary cameras. The disk diameter was 7.″3 of arc.

The slowly shrinking North Cap appeared sharp and clear of haze. Antarctic white frost was observed on some of the light-area islands or plateaux.

A morning terminator low-altitude blue haze was over the Zephyria–Elysium region. High-altitude violet-light evening cloud concentrations were present over the Xanthe–Candor–Thaumasia region from 50° to 90° long., −30° to +20° lat. A medium-altitude blue-light cloud covered the Candor–Tharsis region and extended band-like across the Amazonis desert from 70° to 180° long.; −5° to +20° lat. A sunset limb haze extended from +30° to about −40° lat. No blue-clearing was detected.

A bright early morning frost was suspected on the Elysium area.

The southern maria still held dark seasonal contrast. The northern fine detail was losing contrast. The Propontis complex, Scandia–Boreum region, and the broad Hades canal were of medium dark gray contrast. The Nilokeras I and II and Ganges canals were a medium gray contrast. The Ceraunius, Gigas, Brontes, and Titan canals were not observed.

**June 25, 1965**; 0430–0445 UT; CM 103°; MD 1 August. The 30-inch Cassegrain employed 300× and 560× and a camera.

The North Cap was poorly observed in the bad seeing conditions.

A large morning blue-white cloud was seen on the terminator over the Amazonis–Mesogaea region at 170°

long., 0° lat. ca. An evening limb haze was centered near the equator at approximately 40° longitude over the Chryse–Xanthe desert. No atmospheric blue-clearing was noted.

Little surface detail was seen because of poor astronomical seeing conditions.

**June 26, 1965;** 0445–0500 UT; CM 97°; MD 2 August. The 30-inch reflector employed a 560× ocular.

The North Cap was small and circular and haze-free. A weak antarctic haze was possibly seen.

A large morning terminator cloud was present over the Amazonis–Mesogaea region at the position 167° long.; 0° lat. ca. An evening limb haze was located over the Chryse–Xanthe desert at 40° long., +10° lat. ca. No blue-clearing was detected in violet light.

No surface detail was observed crossing the great expanse of the Tempe–Arcadia–Amazonis desert. Only the medium dark gray Mare Acidalium was vaguely seen in the poor astronomical seeing conditions.

**June 27, 1965;** 0330–0355 UT; CM 68°; MD 2 August. The 30-inch Cassegrain used a 560× ocular.

The white North Cap was clearly seen and it appeared to have a smaller measured diameter than it had on June 23 TD. A possible weak antarctic haze was seen.

Heavy morning cloud was over the Tharsis–Arcadia–Amazonis desert. An evening haze persisted over the −40° to +50° latitudes. No blue clearing was detected. No "green-haze" was seen.

White frost was indicated in yellow-green light on the Nix Cydonia area in the Cydonia desert.

The dark gray-green Mare Acidalium was the prominent surface feature. The Nilokeras I and II canals were still observable.

The Martian planetary disk was small and becoming difficult to observe because of its low-altitude position above the Earth's western horizon.

**June 28, 1965;** 0416–0458 UT; CM 75°; MD 3 August. The 30-inch Cassegrain employed 560× and cameras.

The North Polar Cap was not clearly seen this evening, due to an evening limb haze. An evening limb haze was also present in the antarctic region.

The evening limb haze extended from the north polar region, across the equator, and into the south polar realm. A violet-light sunset cloud concentration was present over the Edom area. Large morning clouds still persisted over the Tharsis–Amazonis region. The Martian atmosphere was uniformly opaque to violet and blue light.

The Mare Acidalium appeared a gray-green and mottled brownish hue. The Nilokeras I and II canal system was broad and held good seasonal contrast. No fine surface detail was observed.

**June 29, 1965;** 0420–0455 UT; CM 65°; MD 3 August. The 30-inch Cassegrain used 560× and a planetary camera. The axial tilt was +25°. The terminator width was 40°. The disk diameter was 7″ of arc.

The North Cap was sharply defined, clear of haze, and smaller in diameter. The Cap measured about 16° in diameter.

The evening limb haze was not as dense and it was less extensive, covering the +70° to −40° latitudes. The morning cloud over the Tharsis–Amazonis desert was not as dense as formerly observed, and it covered the area 110° to 140° long.; −10° to +25° lat. No "green-haze" was observed over the Tempe–Arcadia desert region in the 60° to 135° longitudes. The atmosphere was completely opaque and uniform to violet light.

A bright, white frost was evident on the Nix Cydonia in the Cydonia desert, and it contrasted sharply with the preceding side of the dark gray Acidalium.

The Aurorae Sinus was a dark gray to black shade. The Margaritifer Sinus was a medium gray-blue and brown color. The Mare Acidalium held a medium gray to dark gray-green contrast.

**June 30, 1965;** 0338–0510 UT; CM 50°; MD 4 August. The 30-inch Cassegrain reflector employed a 560× ocular and cameras.

The small circular North Polar Cap was well defined, clear of haze, and easily seen. Nothing was seen in the antarctic region.

A small evening cloud was positioned over the Eden desert from about $-5°$ to $+15°$ latitude. A morning low-altitude fog-type cloud was evident over the Candor–Tharsis desert and over the south part of the Tempe desert at approximately 70° to 100° long.; $-10°$ to $-30°$ lat. No blue-clearing was observed in violet light.

The Nix Tanaica was an extremely light shade, and possibly frost-covered.

The Aurorae Sinus was a dark gray shade showing good contrast to the ocher Chryse and Thaumasia deserts. The Mare Acidalium appeared to have a medium contrast with a gray and brown coloration. The Nilokeras I and II and the Ganges canals held a good dark gray contrast, and they were still quite broad and seasonally filled in with a lighter shade of gray.

**July 2, 1965**; 0335–0426 UT; CM 25°; MD 5 August. The 30-inch reflector used a 560× ocular and planetary cameras.

The North Cap was white and free of polar haze. The Cap was still slowly regressing back toward the Pole. A southern whitening, possibly on the Noachis, was clearly seen, and it appeared as a pseudo south cap.

The general appearance of the Martian atmosphere showed much less haze and cloud present. No limb or terminator haze was present. Only one small sunset cloud was observed over the Aeria desert. No atmospheric blue-clearing was detected in violet light.

The Mare Acidalium and Nilokeras canals appeared the same as formerly observed.

**July 8, 1965**; 0331–0425 UT; CM 321°–334°; MD 8 August. The 16-inch reflector employed 666×. Axial tilt $+25°$. Terminator width 40°. The disk diameter was only 6″.7 of subtended arc.

The North Cap visually appeared larger than expected for the Martian date of 8 August. No northern peripheral melt-band was present.

The atmospheric disk was opaque to violet and blue light. A sunset recurrent cloud was observed over the Elysium plateau. The atmosphere was clear of haze.

The Hellas plateau was covered with white frost, creating a pseudo south cap.

The Utopia–Boreosyrtis region was a dark gray shade. The Syrtis Major was the most prominent feature on the planet. The Syrtis was a gray-blue to a green-blue color. The gray Thoth–Nepenthes and Protonilus canals were easily observed.

**July 9, 1965**; 0330–0430 UT; CM 320°; MD 9 August. 30-inch Cassegrain instrument used 560× and cameras.

The slowly melting North Cap was bright white and clear of haze. No polar haze was detected.

Much less atmospheric haze and cloud activity was noted this evening. No morning terminator haze or cloud was present. One small evening cloud was recorded over the Aethiopis–Isidis Regio deserts. No atmospheric blue-clearing or "green-haze" was detected.

The white Hellas feature was not as bright as the small North Cap.

No apparent change was noted in the gross dark surface features. Colorimetry of the dark surface detail was not possible because of the conditions of observation.

**July 10, 1965**; 0412–0420 UT; CM 312°; MD 9 August. The 16-inch reflector was used visually with powers of 400× and 666×.

The North Cap was still a shrinking bright white compass free of arctic haze. No antarctic haze was detected.

A possible small sunset cloud still persisted over the western part of the Aethiopis and over the Isidis Regio. No atmospheric blue-clearing was detected in violet light.

High wind on the telescope prevented accurate surface-detail observation.

**July 11, 1965**; 0358–0515 UT; CM 300°–319°; MD 10 August. The 30-inch and 16-inch Cassegrain instruments employed 560× and 400×, respectively.

The North Cap appeared to have temporarily halted its regression. No polar haze was observed at either end of the disk.

A tenuous evening cloud was confined to the Aethiopis area. No morning terminator haze was recorded. The Martian atmosphere was opaque to violet and blue light.

The Hellas plateau was covered with hoarfrost, but it was not as bright as the small North Cap. The Elysium area shone brightly on the sunset limb, and yellow-green light (W-57) indicated the presence of ice-fog or hoarfrost.

The Syrtis Major was a green-blue hue. The Wedge-of-Casius, Utopia, and Boreosyrtis region was a medium gray shade, and losing contrast. The broad Thoth–Nepenthes canal was a medium gray shade. No fine surface detail was evident on the small Martian disk.

**July 13, 1965**; 0310–0500 UT; CM 268°–292°; MD 11 August. The 30-inch and 16-inch Cassegrain reflectors employed planetary cameras and 400×, 560×, and 666×. The axial tilt was +25°. The terminator width was 40°. The disk diameter was 6″.5 of arc.

The North Cap had slowed its rate-of-change to a minimum with a measured disk diameter of about 12°. There was possibly a tenuous arctic haze over the Cap. No antarctic haze was recorded.

The Martian atmosphere was becoming extremely clear of visible moisture. No sunset limb or sunrise terminator haze was detected. A weak visual blue-clearing was detected independently at Flagstaff and at Table Mountain in the northern hemisphere, and confirmed on the violet and blue photographic images. The Thoth canal, Utopia, and Boreosyrtis region was clearly seen and recorded in violet light. One very small bright area of ice-fog or hoarfrost was seen on the evening limb over the Elysium plateau.

The Syrtis Major was a prominent green-blue-gray feature. The Casius area was a medium contrast gray. The Mare Tyrrhenum was a dark purple. The Sabaeus Sinus was a black-blue hue. The southern maria displayed good seasonal coloration. The gracefully curved Thoth canal was filled in with a medium gray contrast, causing the canal to appear as a broad, gray, single feature. The Nilosyrtis, Alcyonius, and Protonilus canals were recorded. The Nodus Laocoontis was not seen.

**July 14, 1965**; 0344–0420 UT; CM 270°; MD 11 August. The 30-inch and 16-inch telescopes employed cameras and 560× and 320×, respectively.

The North Cap remnant was bright white and free of haze. The cap measured about 6° or 7° in diameter. No antarctic haze was observed.

An atmospheric blue-clearing test was not possible because of poor seeing conditions. No clouds were observed in the Martian atmosphere.

An evening ice-fog or frost was located over the Elysium area.

The poor seeing conditions prevented inspection of the surface detail.

**July 15, 1965**; 0320–0500 UT; CM 251°–275°; MD 12 August. The 30-inch and 16-inch Cassegrain instruments used planetary cameras and 320×, 560×, and 666×. The disk diameter was 6″.5 of arc.

The North Polar Cap remnant was observed through a tenuous arctic haze that covered the Cap. The Cap appeared to be the same size as measured on the preceding observation. Possible scattered ice-fog or hoarfrost patches were seen in the antarctic region. There was no observed evidence for the return of the South Cap in the visible southern latitudes.

The visible moisture activity in the Martian atmosphere had increased somewhat; however, the atmosphere was still extremely clear. No morning haze was present on the terminator. A large evening recurrent cloud was positioned over the Elysium and Zephyria region. No "green-haze" was detected in yellow-green light. A weak atmospheric blue-clearing persisted in the northern hemisphere. The Thoth canal, Wedge-of-Casius, Utopia, and Boreosyrtis region were fairly well observed in violet light (W-47B), and clearly seen in broad blue light (W-38).

The Hellas plateau was covered with a gray-white hoarfrost. The Aeria desert was a very light ocher hue, indicating a possible hoarfrosting on the Nymphaeum area. The Elysium was a light ocher hue, but no definite confirmation of an enduring or forming afternoon white frost was obtained.

The grand Syrtis Major was still a green-blue hue. The Wedge-of-Casius and Boreosyrtis region were a medium gray shade and brown color. The Trivium Charontis was a medium-contrast dark brown and gray feature. The Trivium exhibited only about a 70% of normal contrast relative to formerly observed apparitions.

The curved Thoth canal appeared singular, a good-contrast gray shade, and centrally filled in with a medium gray shade. The Nilosyrtis, Astaboras I, Astusapes, and Vexillum canals were rapidly losing contrast.

**July 16, 1965**; 0345–0425 UT; CM 253°; MD 12 August. The 30-inch Cassegrain used 560× and a camera.

The small North Cap remnant appeared to be of the same physical size as observed previously, and it was seen through a tenuous arctic haze. No antarctic haze was observed. The gray-white Hellas was most prominent in the south polar region. No evidence of the return of the South Polar Cap to this date, which meant that it was not large enough to be seen on the southern limb between the 65° to 45° parallels. The South Cap was not expected to be visible at this season because of the large positive north axial tilt of the planetary disk.

The Martian atmosphere was still relatively clear of visible moisture. A weak evening limb haze was centered over the 180° long., 0° lat. The formerly observed afternoon recurrent cloud over the Elysium–Zephyria region had decreased in extent and density, and was now confined to the Elysium area. Violet-light observation indicated that the northern hemisphere weak blue-clearing still existed.

The Hellas was still covered with frost. No afternoon whitening was observed on the Elysium plateau.

The surface features were vaguely seen and appeared the same as formerly observed.

**July 19, 1965**; 0332–0415 UT; CM 215°–227°; MD 14 August. The 30-inch Cassegrain telescope employed planetary cameras and a 560× ocular. The disk diameter was 6″.4 of arc.

The North Cap remnant had the same 6 to 7 degree diameter as formerly measured. The Cap had apparently reached a static and normal seasonal condition. A tenuous arctic haze covered the Cap. In the south, the gray-white Hellas presented an observed appearance of a pseudo south cap. No antarctic haze was detected.

A narrow, tenuous evening limb haze was seen in blue light extending from about the +20° to the −50° or −60° latitude. No atmospheric clouds were observed in violet, blue, or blue-green light. The same weak blue-clearing was once again detected in violet light in the northern hemisphere.

The Hellas gray-white frost cover appeared to be on the decline, or in the process of sublimation. A morning bright white frost was on the Isidis and Neith Regios.

The beautiful Syrtis Major appeared a blue-green in the morning twilight. The Trivium Charontis was still only a medium contrast, brown color. The Elysium was a light ocher hue. The Umbra, Copais Pons, and Casius Wedge were medium to dark shades of gray. The Panchaia and Utopia areas were fading and becoming gray and mottled brown.

The Hades, Dis, and Gyndes canals still held a good seasonal dark gray contrast.

**July 20, 1965**; 0320–0350 UT; CM 207°; MD 14 August. The 30-inch and 16-inch reflectors were used with cameras and 560× and 320× oculars.

The North Cap remnant had the same 6- to 7-degree diameter as formerly measured. The Cap had apparently reached a static and normal seasonal condition. A tenuous arctic haze covered the Cap. In the south, the gray-white Hellas presented an observed appearance of a pseudo south cap. No antarctic haze was detected.

A narrow, tenuous evening limb haze was seen in blue light extending from about the +20° to the −50° or −60° latitude. No atmospheric clouds were observed in violet, blue, or blue-green light. The same weak blue-clearing was once again detected in violet light in the northern hemisphere.

The Hellas gray-white frost cover appeared to be on the decline, or in the process of sublimation. A morning bright white frost was observed on the Isidis and Neith Regios.

The beautiful Syrtis Major appeared a blue-green in the morning twilight. The Trivium Charontis was still only a medium-contrast brown color. The Elysium was a light ocher hue. The Umbra, Copais Pons, and Casius Wedge were medium to dark shades of gray. The Panchaia and Utopia areas were fading and becoming gray and mottled brown.

The Hades, Dis, and Gyndes canals still held a good seasonal dark gray contrast.

**July 21, 1965**; 0312–0351 UT; CM 190°; MD 15 August. The 30-inch and 16-inch Cassegrain telescopes used a camera and 320×, 400×, 560×, 666×, and 1000×. The disk diameter was a modest 6″.3 of subtended arc.

The static North Polar Cap was very bright white and undoubtedly clear of haze. The existence of low-altitude antarctic haze or a south polar hood was possibly detected in blue-green light.

A bright evening haze or ice-fog was detected over the Arcadia desert at the position 120° long.; +50° lat. No atmospheric blue-clearing was observed in violet light.

The southern light ocher areas of the Phaethontis, Electris, and Eridania appeared a yellow-white in integrated light, and were bright in green and yellow-green light. The Isidis and Neith Regios were covered with a bright early-morning frost.

The Maria Sirenum and Cimmerium were a dark gray shade. The Trivium showed a moderate brown contrast. The dark gray Propontis complex held a good contrast. The Elysium was a definite pink hue. The Scandia–Panchaia region was a variegated light brown and ocher color, and rapidly losing contrast.

The Hades, Dis, and Gyndes canals were fading, but unusually well defined. No surface detail was observed across the Arcadia–Amazonis desert under good seeing conditions.

**August 7, 1965;** 0300–0410 UT; CM 25°; MD 24 August. The 16-inch Cassegrain employed a 315× ocular. The axial tilt was +23°. The disk diameter was 5″.9 of arc.

An observational check was made on the physical size and state of the North Cap. The Cap was still present on the Martian disk, and it appeared to have about the same 6-degree diameter as last observed on July 21 TD.

No atmospheric clouds or surface whitenings were recorded.

The Mare Acidalium was vaguely seen, and it had lost some of its former dark contrast.

**August 25, 1965;** 0335–0400 UT; CM 216°; MD 3 September. The 16-inch Cassegrain telescope employed a 315× ocular. The disk diameter was a modest 5″.5 of arc.

An observational check was again made to see if the North Cap completely disappeared. The small white compass of the North Cap was seen through a tenuous evening arctic haze. No evidence of the South Polar Cap was found.

A bright low-altitude afternoon cloud was recorded over the Memnonia–Mesogaea desert at the position 155° long., −10° lat. ca. The atmosphere appeared to be very bright and free of cloud and haze. No atmospheric blue-clearing was detected in violet light.

A bright white area covered part of the Amazonis desert at a recurrent cloud position.

The Trivium Charontis and Hades canal were vaguely seen during the better moments of the excellent seeing conditions. The Arcadia–Amazonis desert was a dazzling ocher color.

**October 12, 1965;** 0224–0230 UT; CM 87°; MD 1 October. The 16-inch Cassegrain and 6-inch refractor employed 666× and 285×, respectively. The Martian disk diameter was a small 4″.9 of subtended arc.

A last observational check was made on the visibility and physical state of the North Polar Cap. The Cap was clearly seen and it appeared to be still static in physical size. A large polar hood had formed for the season in the antarctic region.

A large morning cloud was located at the coordinates 160° long.; −05° lat. ca. over the Mesogaea–Amazonis desert region. No atmospheric blue-clearing was detected in violet light.

# XI. MARS PICTORIAL ATLAS 1964–1965

The Mars pictorial atlas is a selection of photographs and drawings obtained during the 1964–1965 apparition. It consists of multicolor spectroscopic photographs arranged according to the usual spectral order, where ultraviolet is first on the left and red or infrared light last on the right, for each selected observing period. Black-and-white reproductions of color transparencies in integrated light or in one of the tricolor separation colors of red, green, or blue light are occasionally included in the series. Low-quality images or drawings (*D*) were used only when necessary to fill in large observational data gaps caused from poor observing conditions. The photographic images are either multi-image composites (*M*) or single images (*S*). Refer to Sec. V (Nomenclature and Abbreviations) for the arrangement of the information given below each picture.

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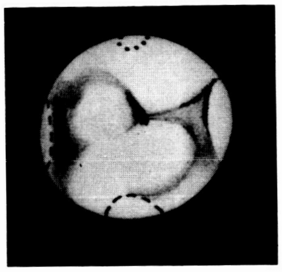

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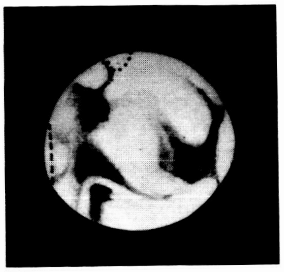

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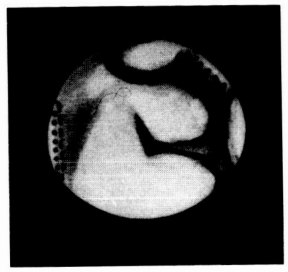

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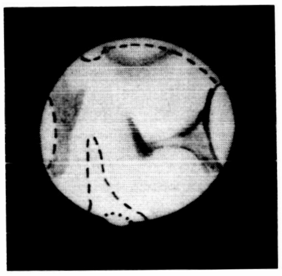

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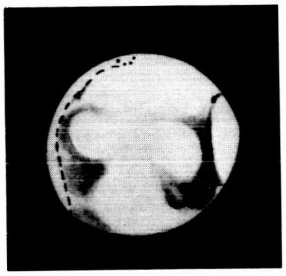

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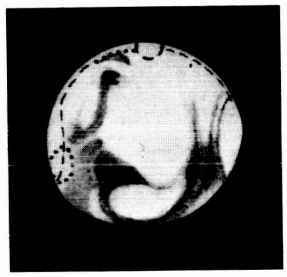

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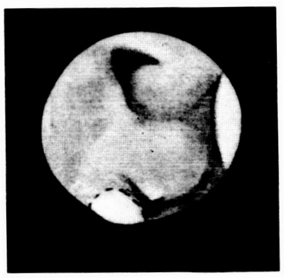

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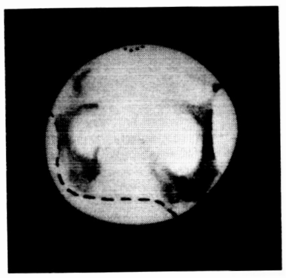

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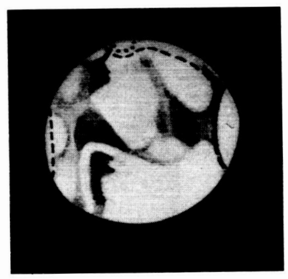

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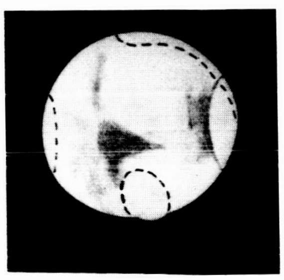

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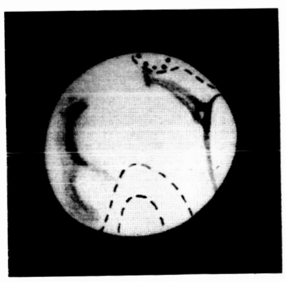

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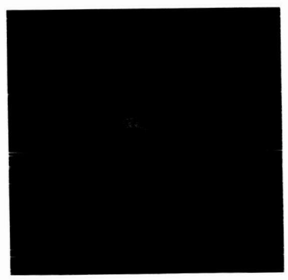

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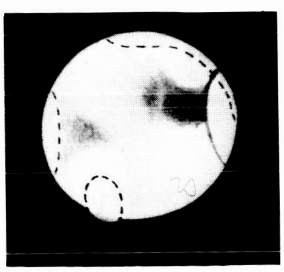

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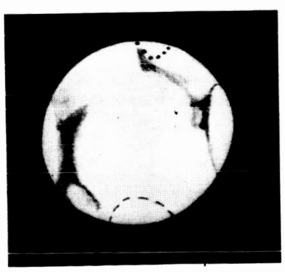

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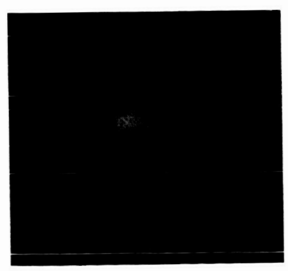

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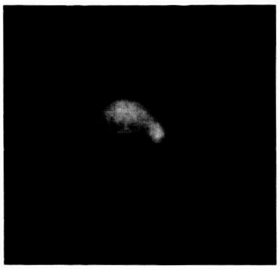

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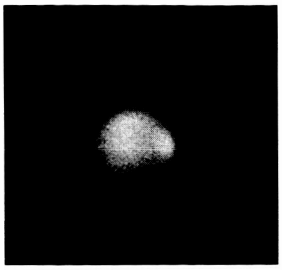

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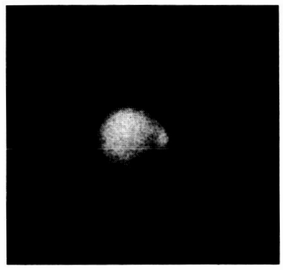

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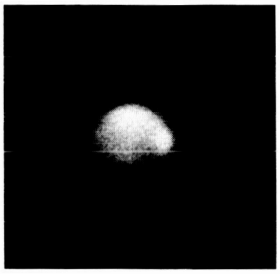

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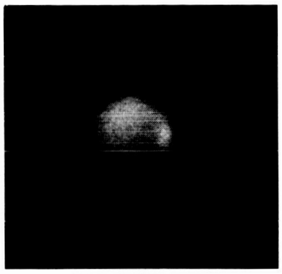

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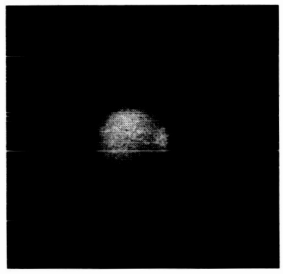

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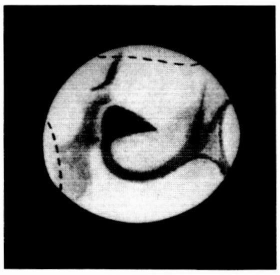

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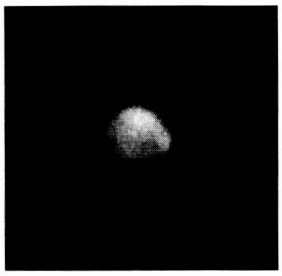

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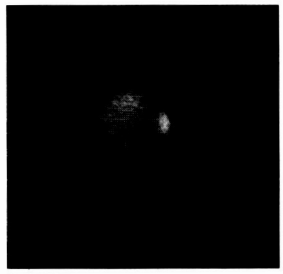

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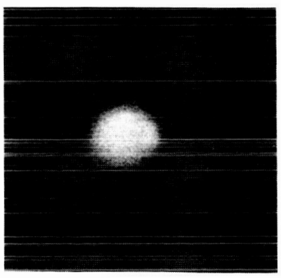

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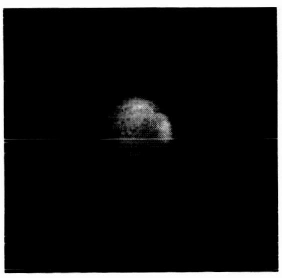

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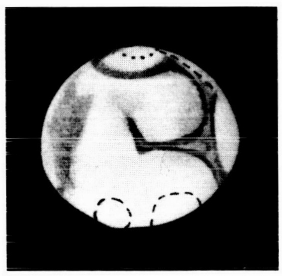

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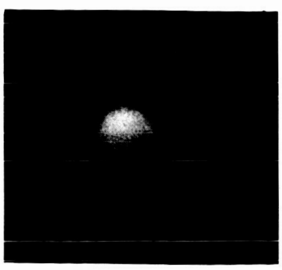

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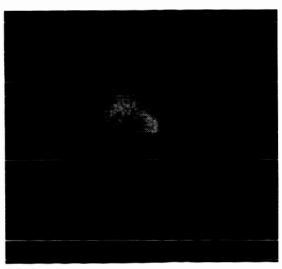

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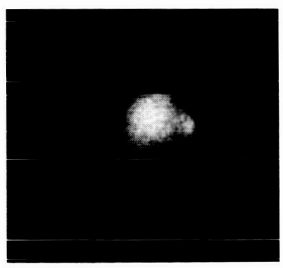
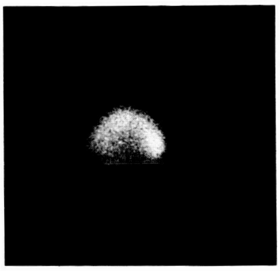


64 12 14 O
CM 203° 3622
S MD 3 May



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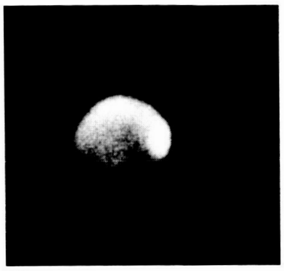
M MD 11 May



65 01 02 UV
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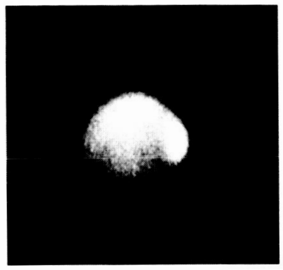
M MD 11 May



65 01 09 CB
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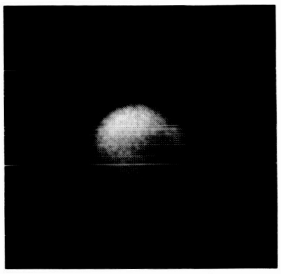
S MD 15 May



64 12 30 O
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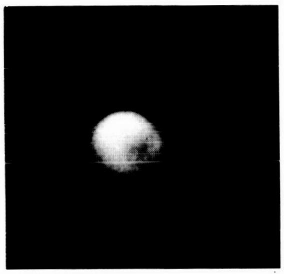
S MD 10 May



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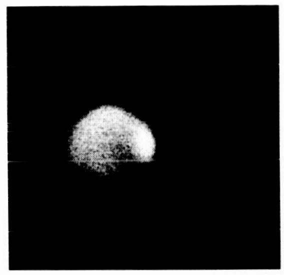

65 01 09 B
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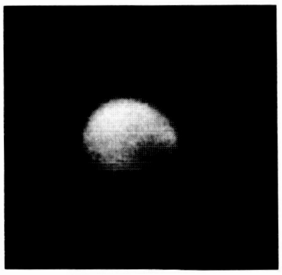
M MD 15 May



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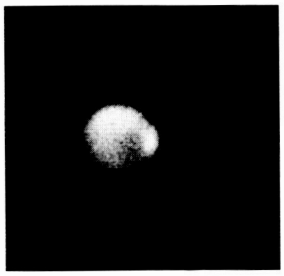

65 01 01 G
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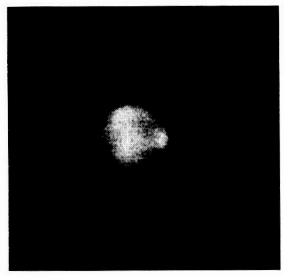

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64 12 30 B
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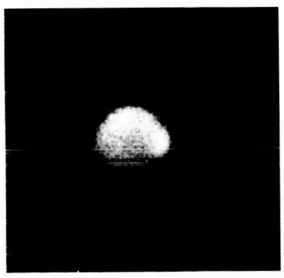

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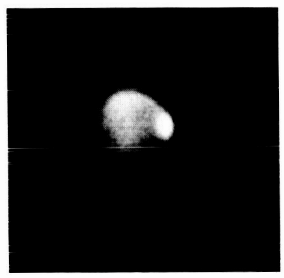

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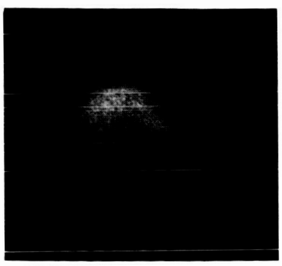

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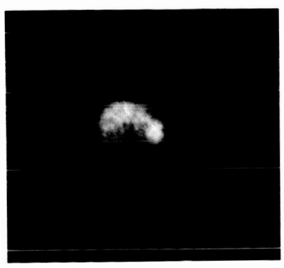

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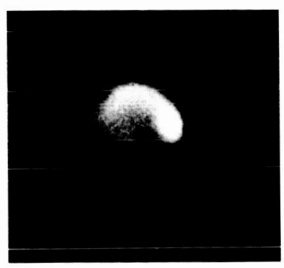

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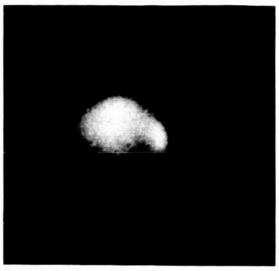
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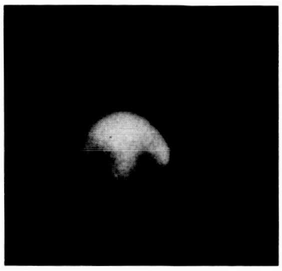
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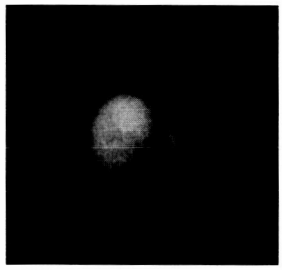
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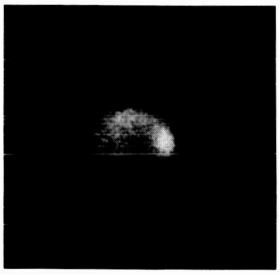
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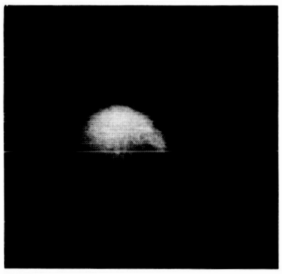
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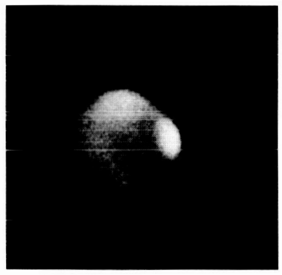
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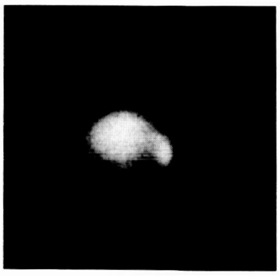
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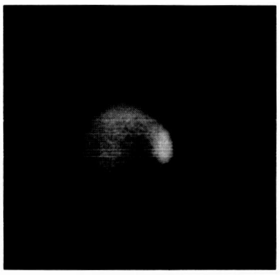
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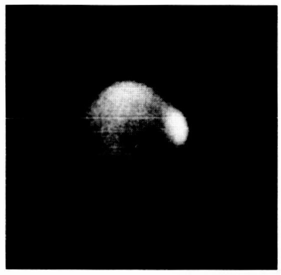
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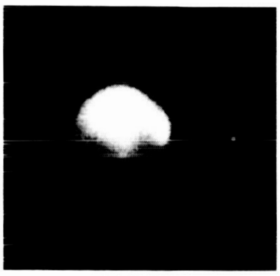
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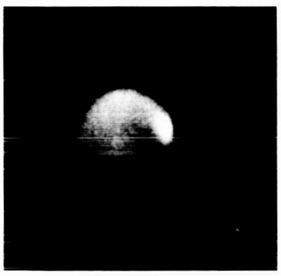
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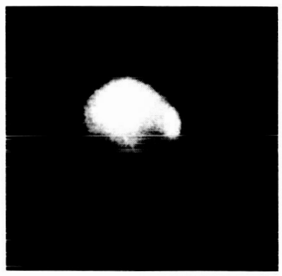
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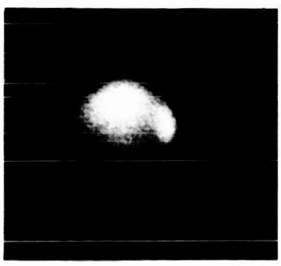
65 01 09 CG
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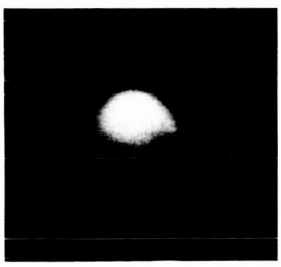
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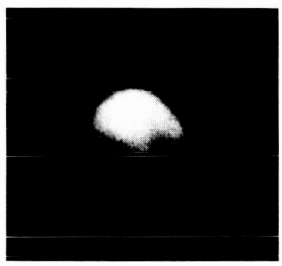
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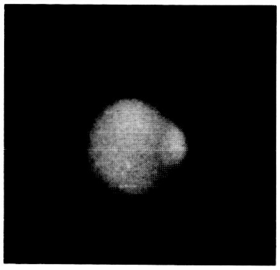

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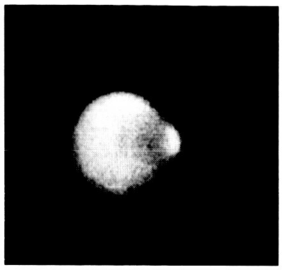

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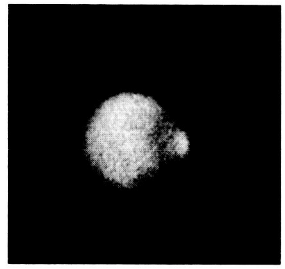

65 01 29 G
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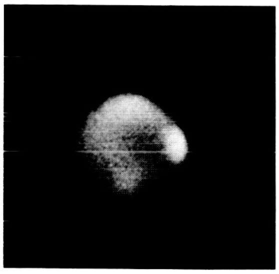

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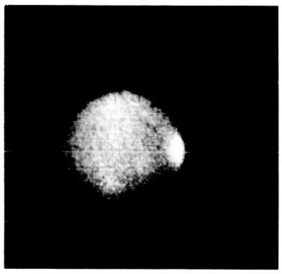

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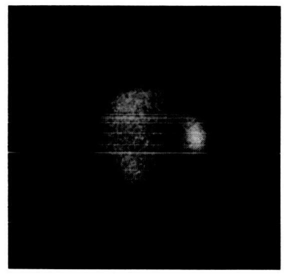

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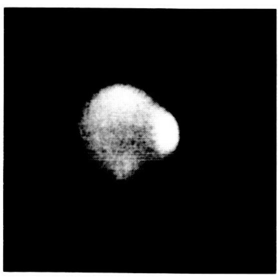

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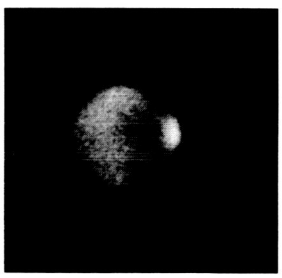

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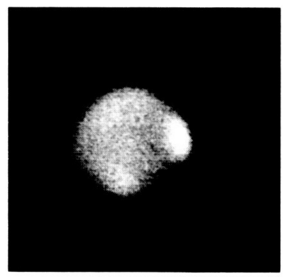

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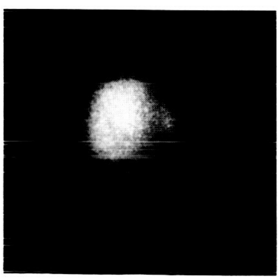

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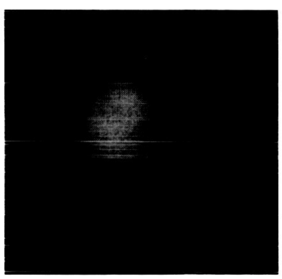

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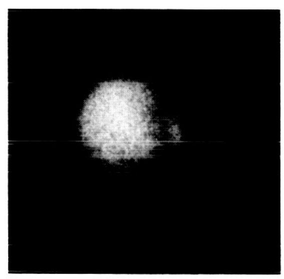

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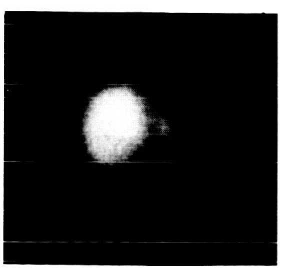

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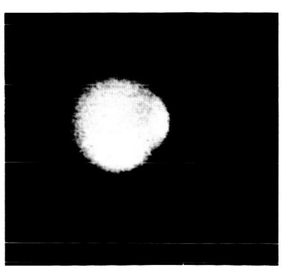

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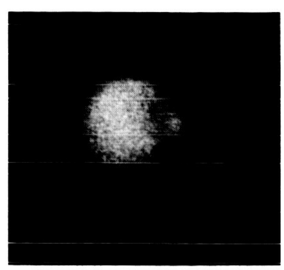

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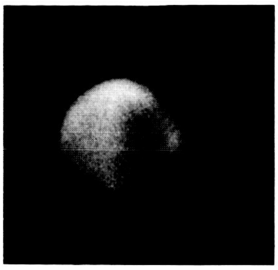

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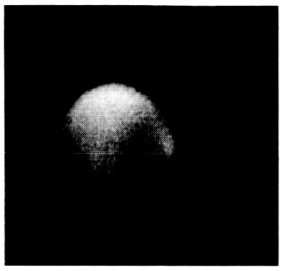
M MD 26 May



65 02 02 CB
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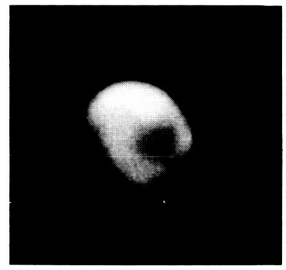

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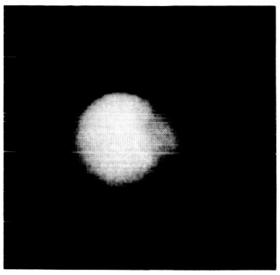

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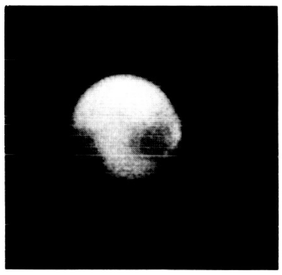

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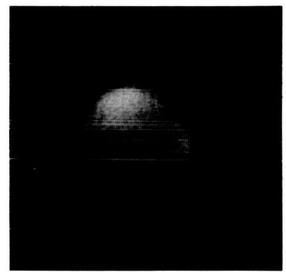

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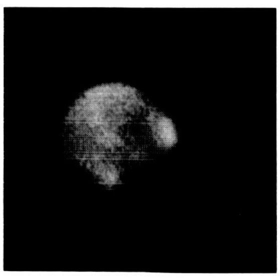

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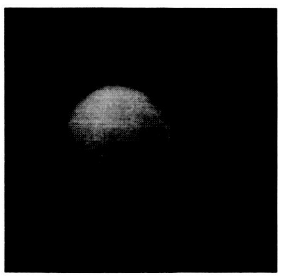

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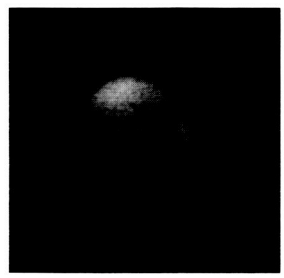

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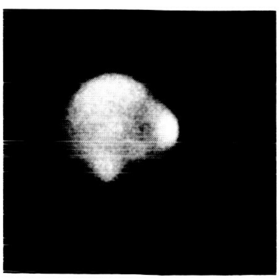

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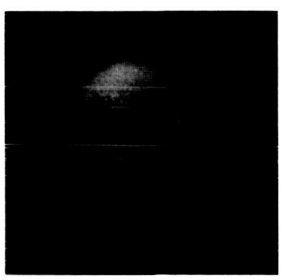

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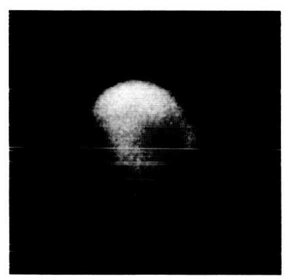

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65 01 29 CI
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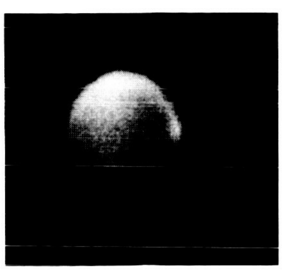

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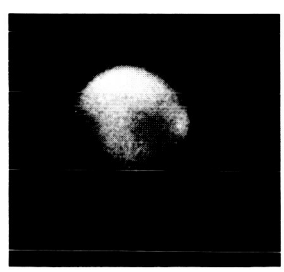

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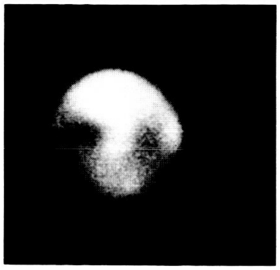

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65 02 16 O
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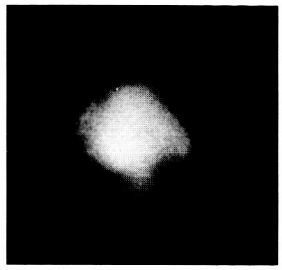

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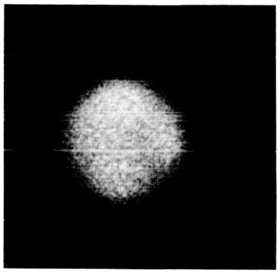

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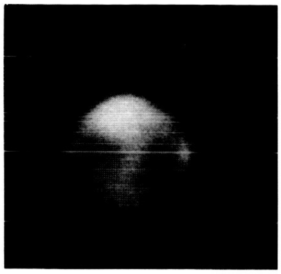

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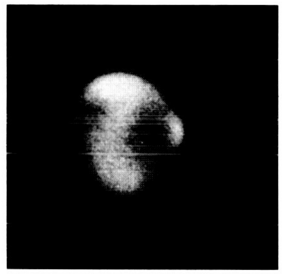

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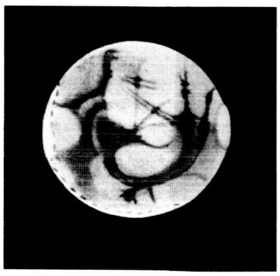

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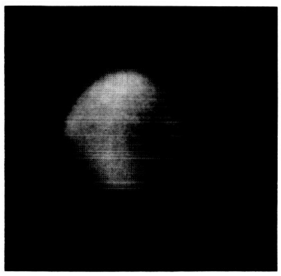
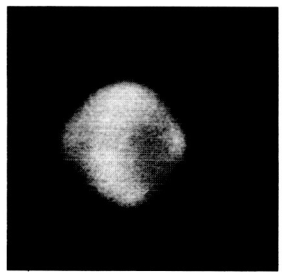


65 02 16 B
CM 281° 3919
M MD 1 June



65 02 17 B
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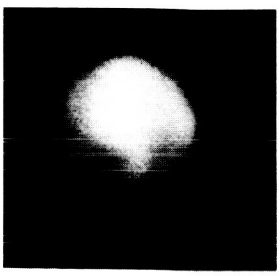

65 02 13 O
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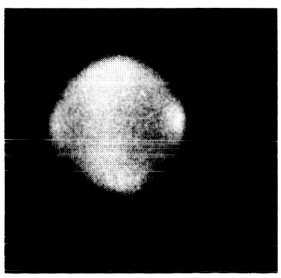
M MD 31 May



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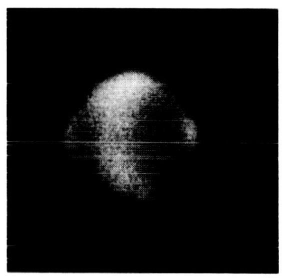

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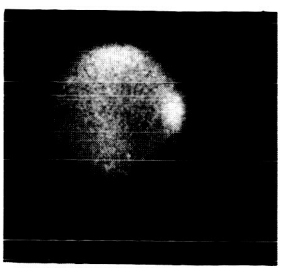

65 02 13 B
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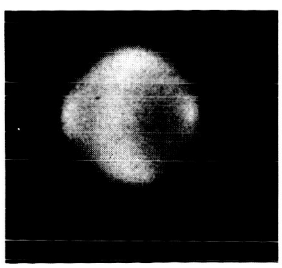
M MD 31 May



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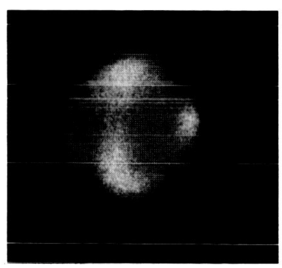

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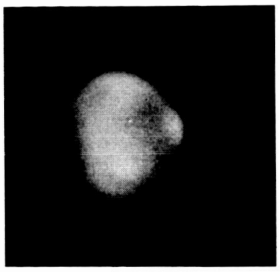
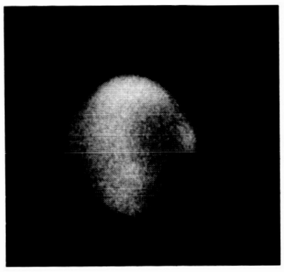


65 02 18 G
CM 239° 3952
M MD 2 June



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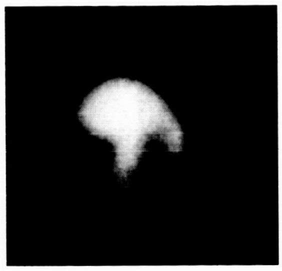

65 02 19 IR
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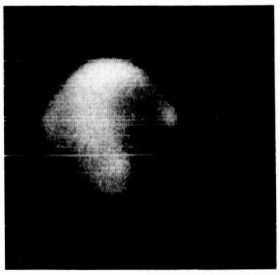

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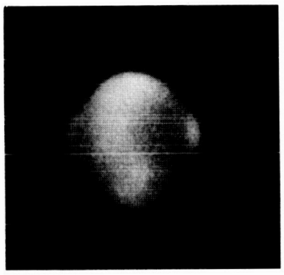

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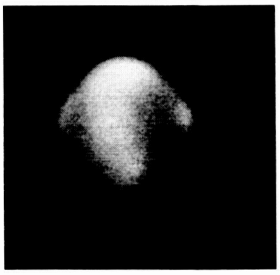
65 02 19 CR
CM 264° 3966
S MD 2 June



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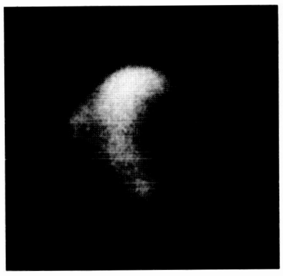

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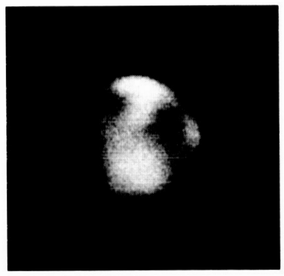

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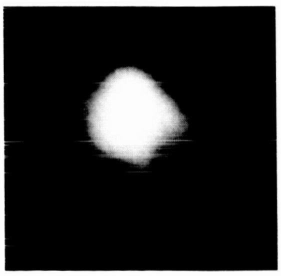

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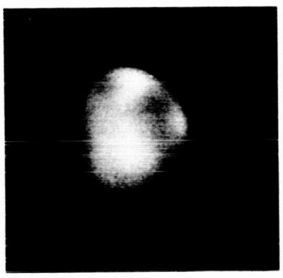

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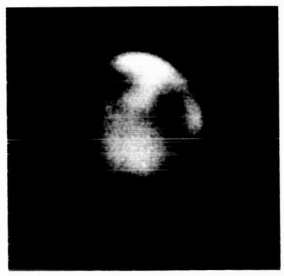

65 02 19 O
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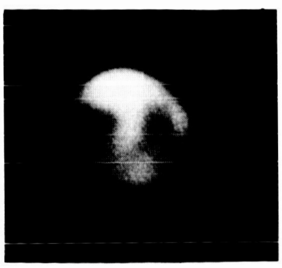

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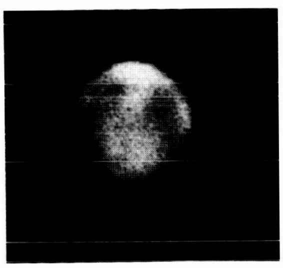

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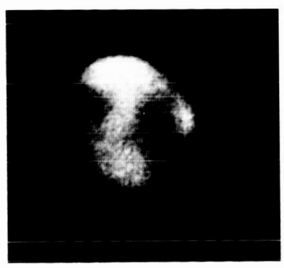

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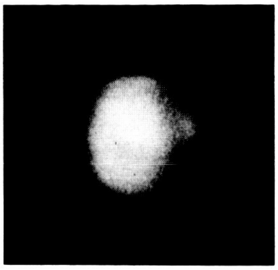

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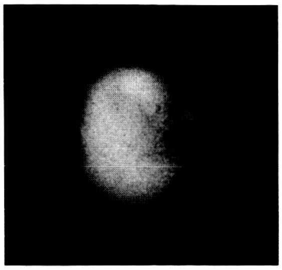

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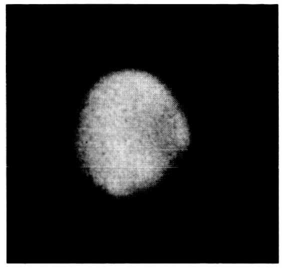

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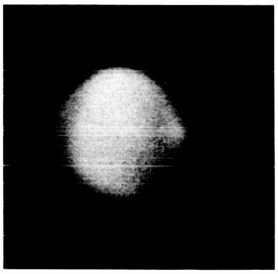

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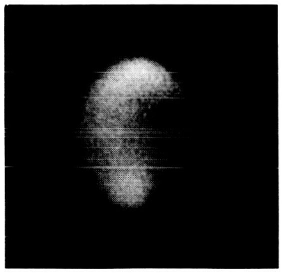

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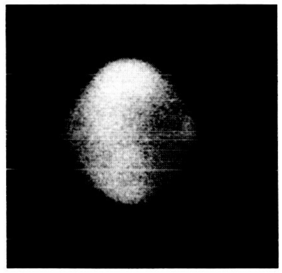

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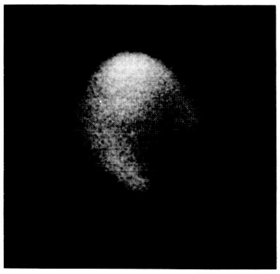

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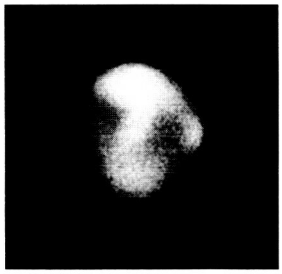

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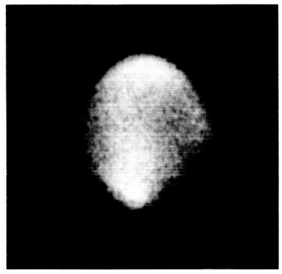

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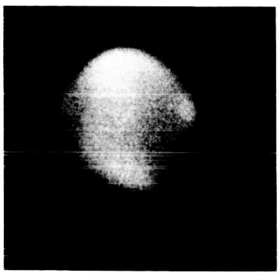

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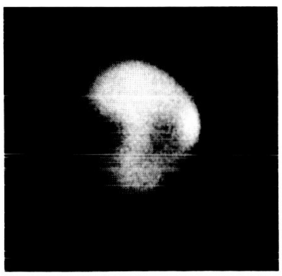

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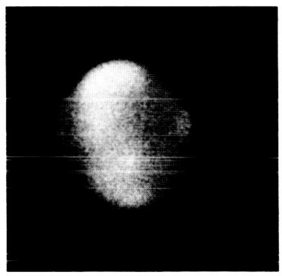

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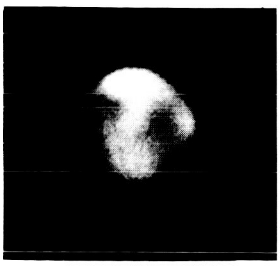

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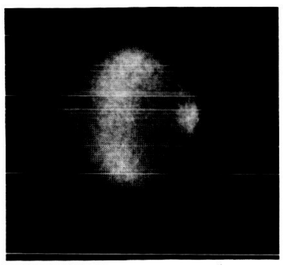

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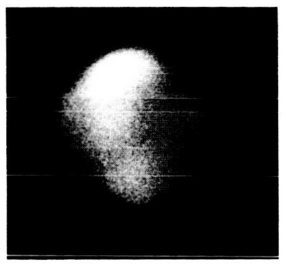

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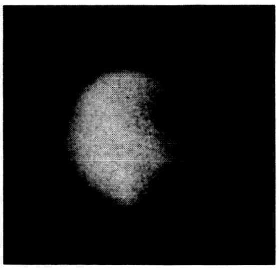

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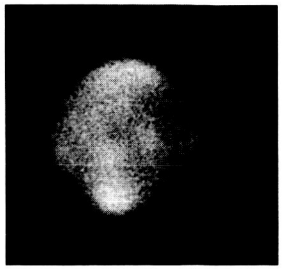

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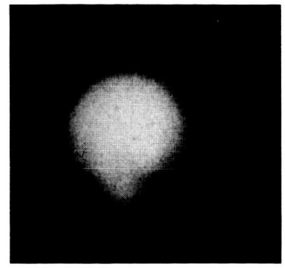

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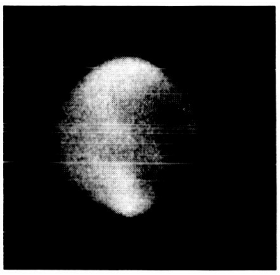

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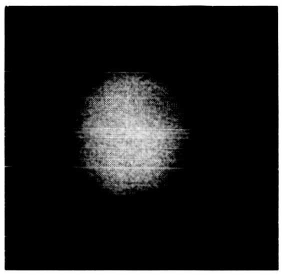

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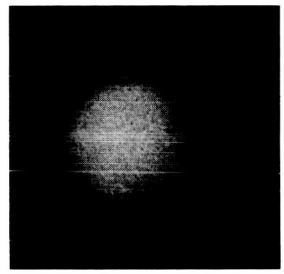

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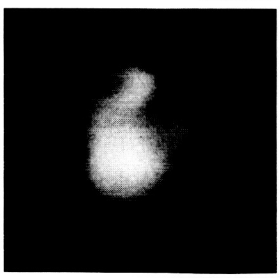

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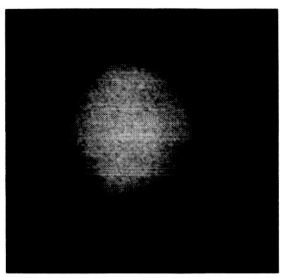

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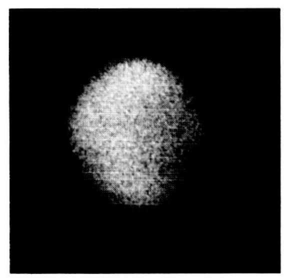

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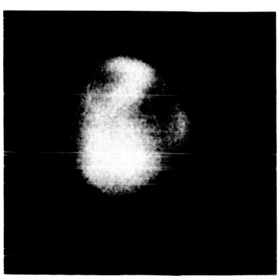

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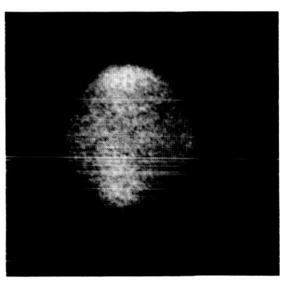

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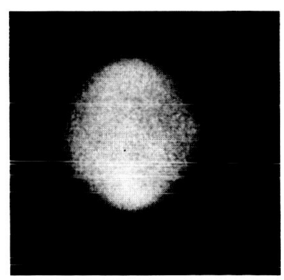

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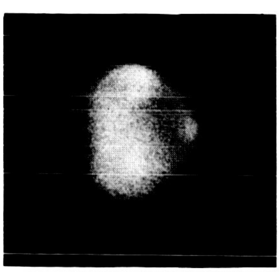

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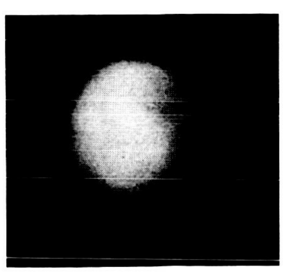

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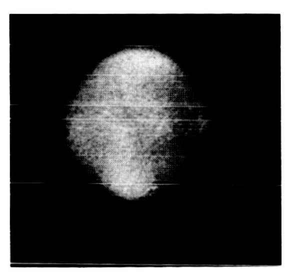

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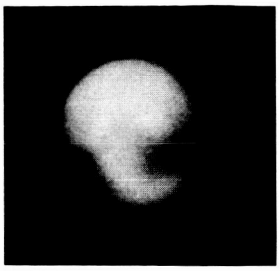

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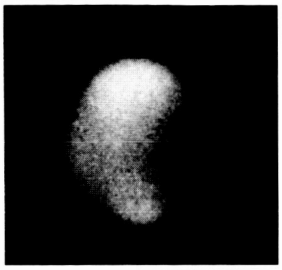

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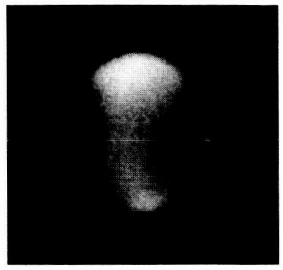

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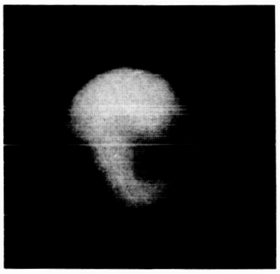

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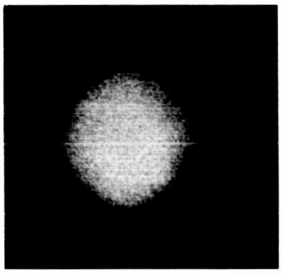

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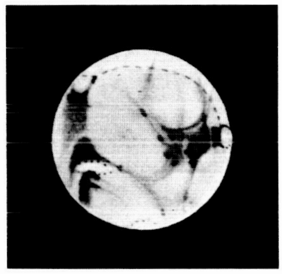

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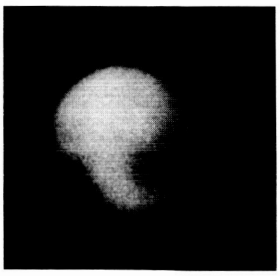

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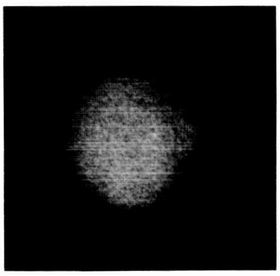

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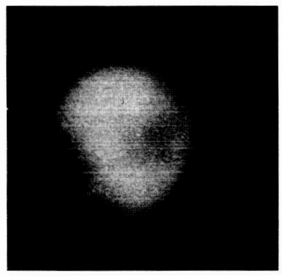

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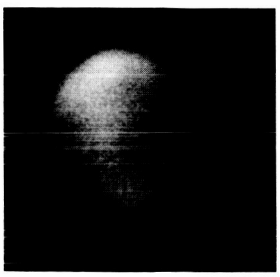

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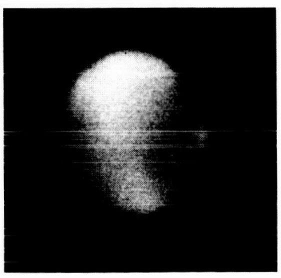

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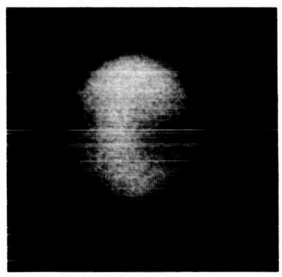

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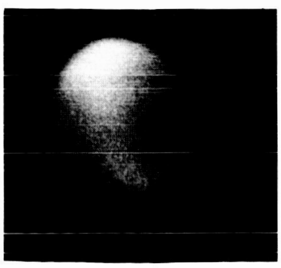

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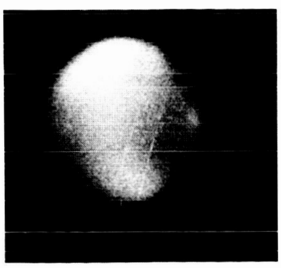

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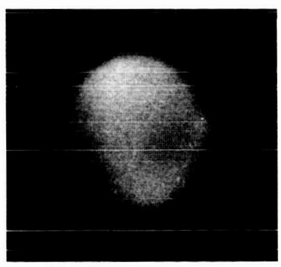
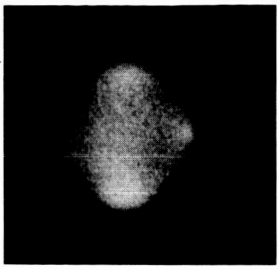
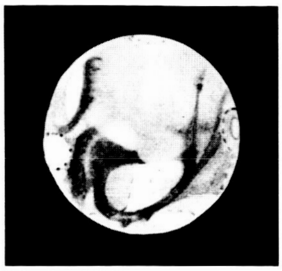


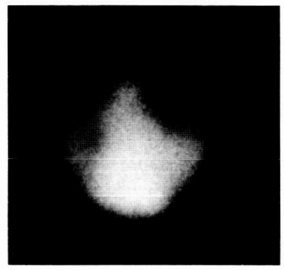
65 03 10 B
CM 52° AG18
S MD 11 June



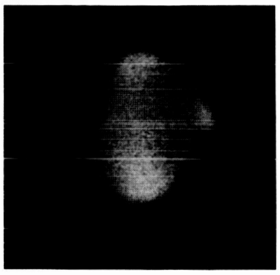
65 03 16 B
CM 328° 4073
M MD 14 June



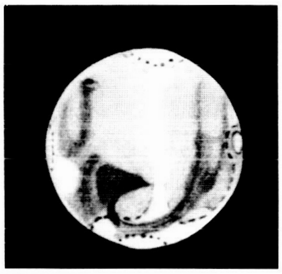
65 03 19 I
CM 304° AG29
D MD 15 June



65 03 19 O
CM 10° 4087
M MD 15 June



65 03 16 V
CM 335° 4077
M MD 14 June



65 03 18 I
CM 305° AG26
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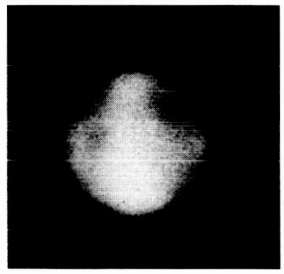
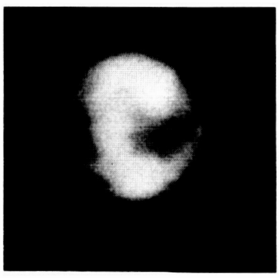
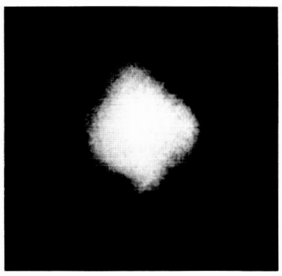


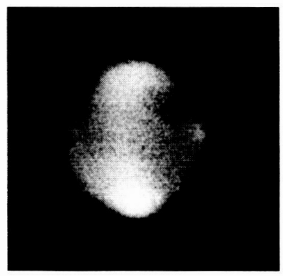
65 03 19 G
CM 13° 4088
M MD 15 June



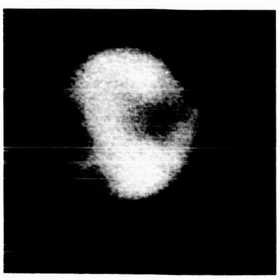
65 03 15 R
CM 43° AG23
S MD 13 June



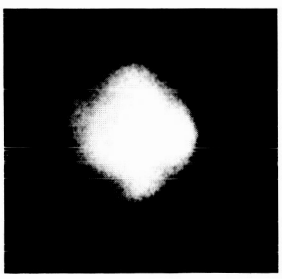
65 03 16 R
CM 333° 4076
M MD 14 June



65 03 19 B
CM 15° 4089
M MD 15 June

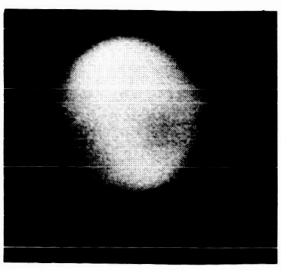


65 03 15 CR
CM 35° AG21
S MD 13 June

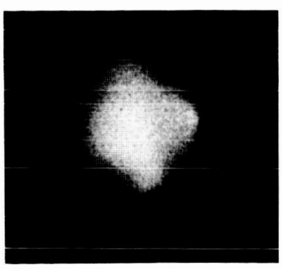


65 03 16 O
CM 333° 4075
M MD 14 June

65 03 19 V
CM 17° 4090
M MD 15 June

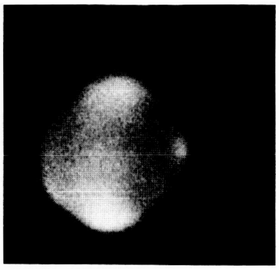


65 03 15 G
CM 55° AG25
S MD 13 June



65 03 61 G
CM 328° 4074
M MD 14 June

65 03 19 I
CM 02° AG36
D MD 15 June



65 03 20 B
CM 349° 4096
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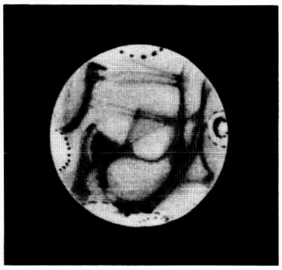

65 03 21 I
CM 306° AG45a
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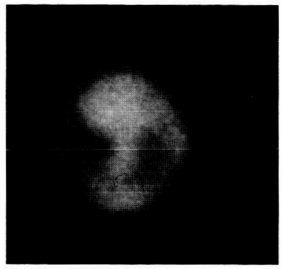
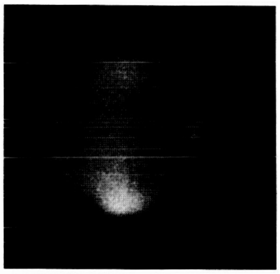


65 03 21 O
CM 297° 4111
S MD 16 June



65 03 20 V
CM 352° 4097
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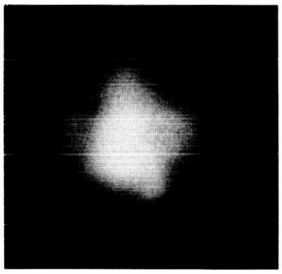
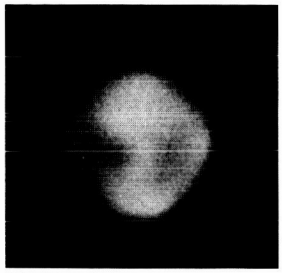


65 03 20 IR
CM 342° 4092
M MD 16 June



65 03 21 G
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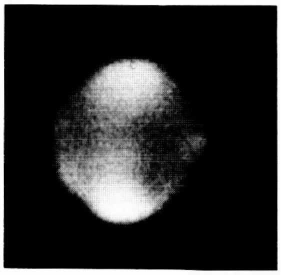

65 03 20 UV
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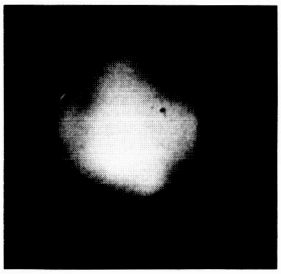

65 03 20 R
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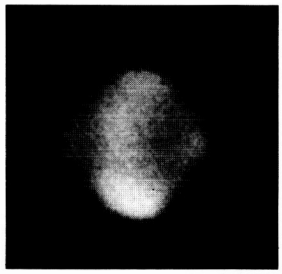

65 03 21 B
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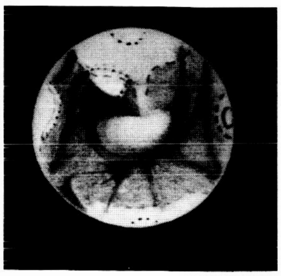

65 03 20 I
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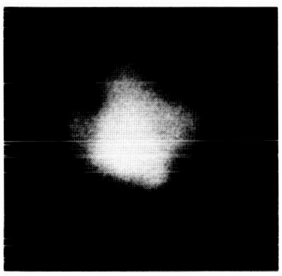

65 03 20 O
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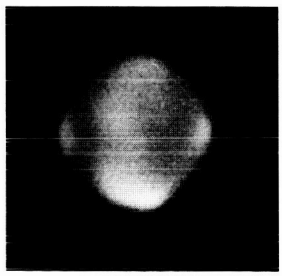

65 03 21 V
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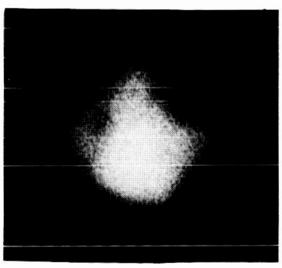

65 03 19 R
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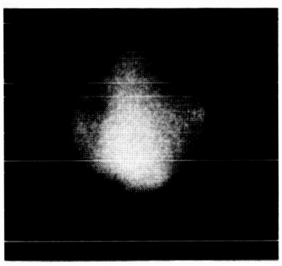

65 03 20 G
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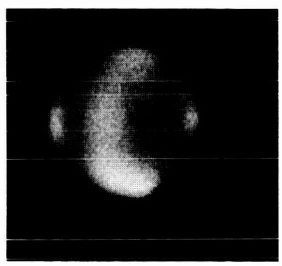

65 03 21 UV
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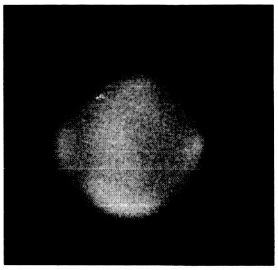
65 03 23 V
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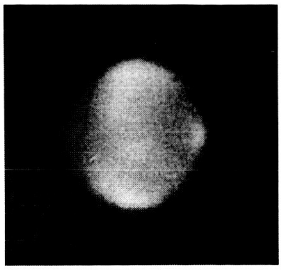
65 03 27 V
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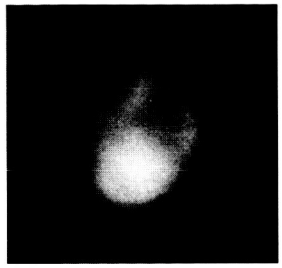
65 03 28 R
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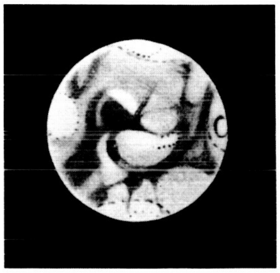
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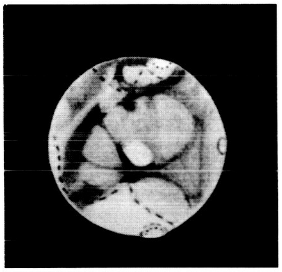
65 03 27 I
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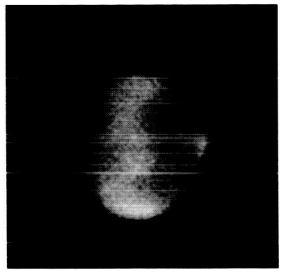
65 03 28 CB
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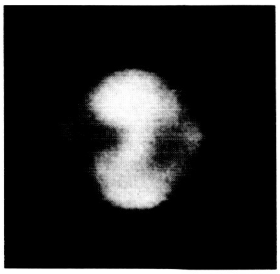
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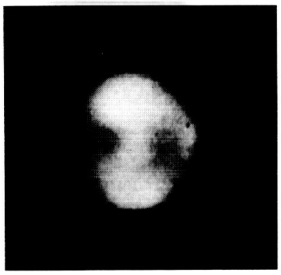
65 03 23 CI
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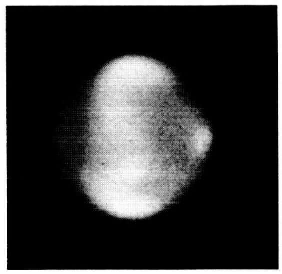
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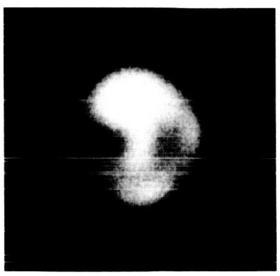
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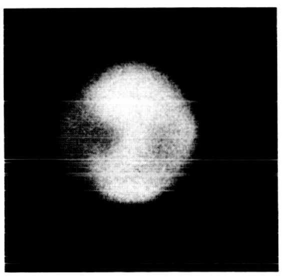
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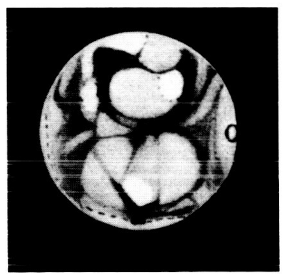
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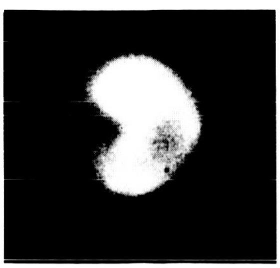
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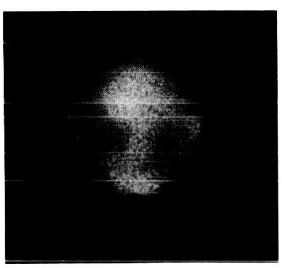
65 03 23 G
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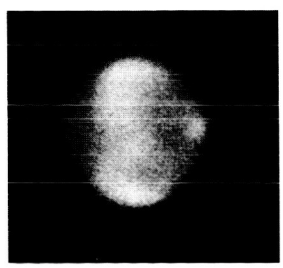
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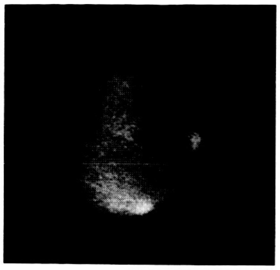

65 03 30 CB
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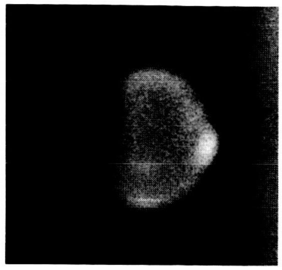

65 03 30 V
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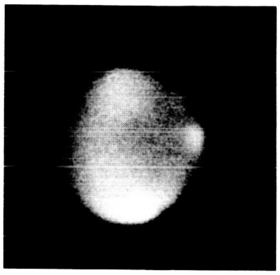
65 03 31 I
CM 210° AG103
D MD 21 June



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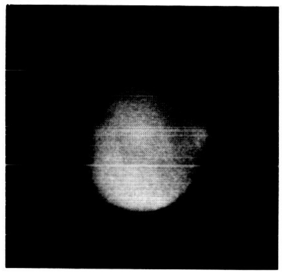

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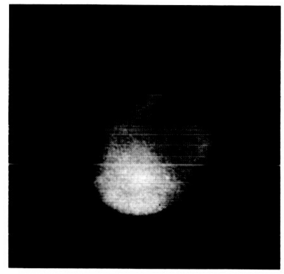

65 03 30 CI
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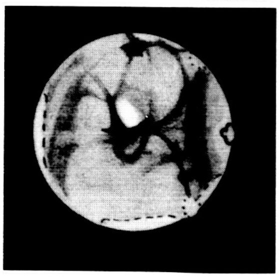

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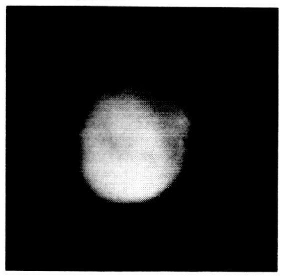

65 03 30 R
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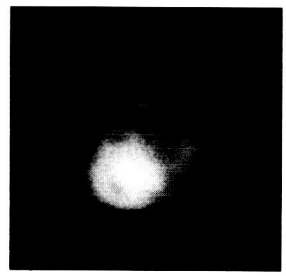

65 03 30 R
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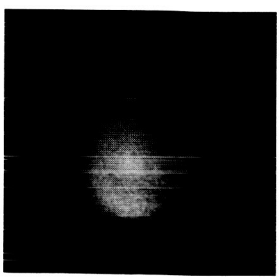
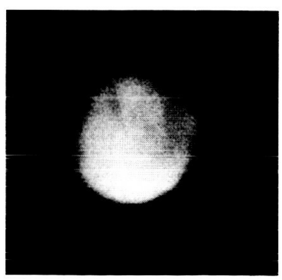


65 03 28 CI
CM 238° AG63
M MD 19 June



65 03 30 O
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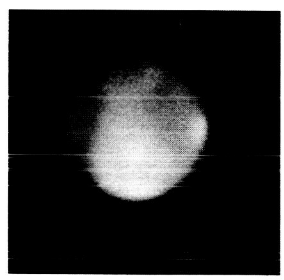

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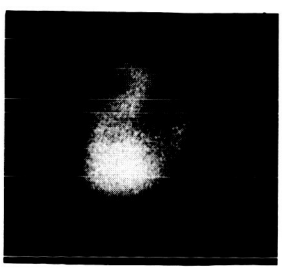

65 03 28 CR
CM 257° AG69
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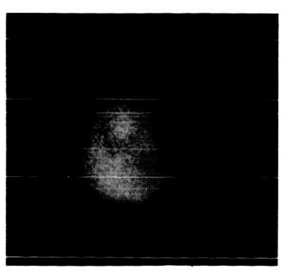

65 03 30 CG
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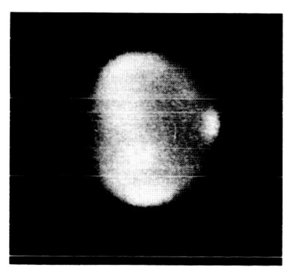

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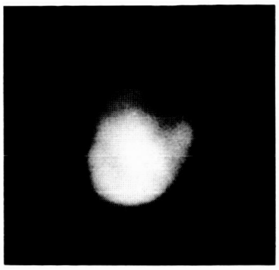
CM 242° AG84
M MD 20 June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CM 228° AG99
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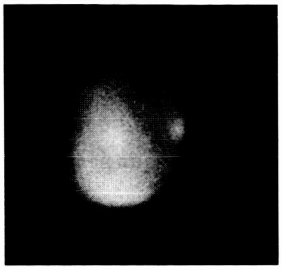
65 03 31 G
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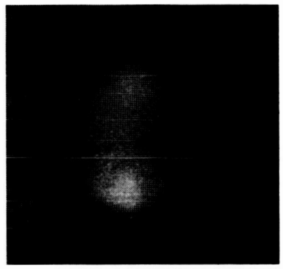
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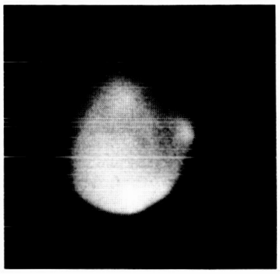
65 03 31 G
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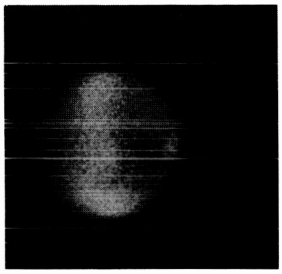
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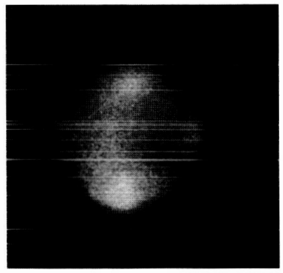
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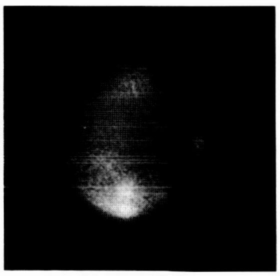
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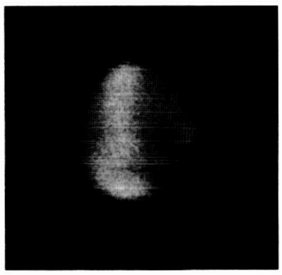
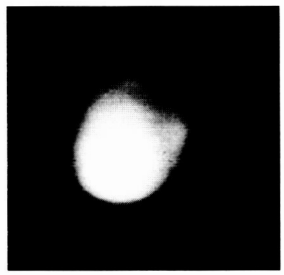
M MD 21 June


65 03 31 V
CM 233° AG101
M MD 21 June


65 03 31 R
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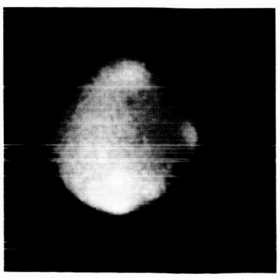
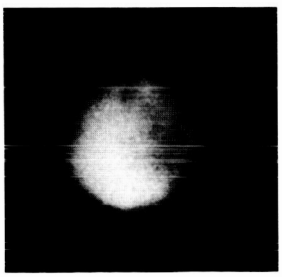
M MD 21 June


65 03 31 CB
CM 175° AG88
S MD 21 June


65 03 31 CR
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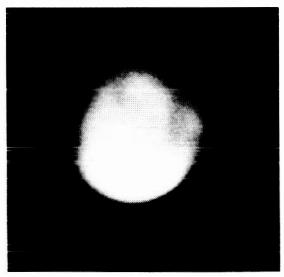
65 03 31 R
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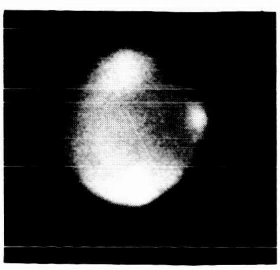
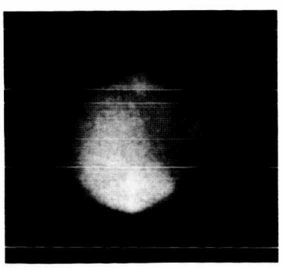
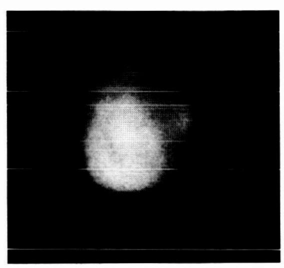
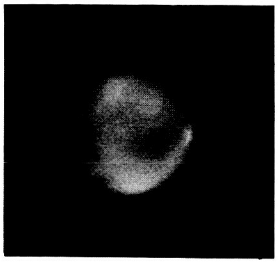
M MD 21 June

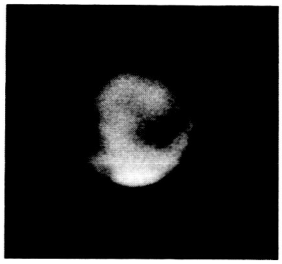

65 03 31 V
CM 184° AG91
M MD 21 June


65 03 31 CG
CM 175° AG88
S MD 21 June

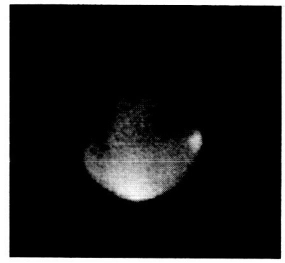

65 03 31 O
CM 226° AG97
M MD 21 June



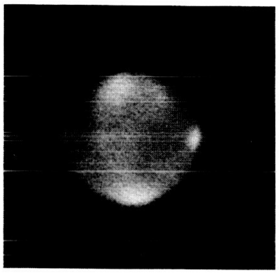
65 04 16 G
CM 66° AG115
S MD 28 June



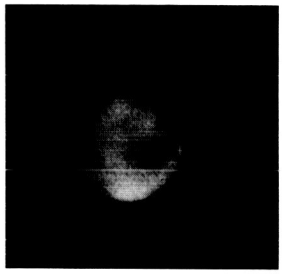
65 04 16 CR
CM 63° AG114
S MD 28 June



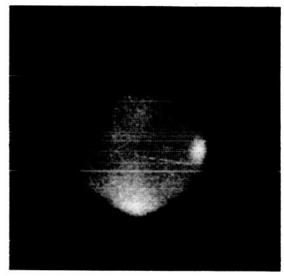
65 04 20 CB
CM 24° AG127
S MD 30 June



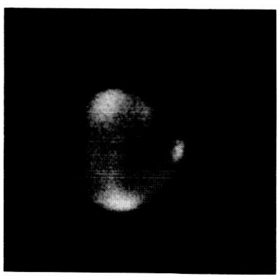
65 04 16 B
CM 56° AG111
M MD 28 June



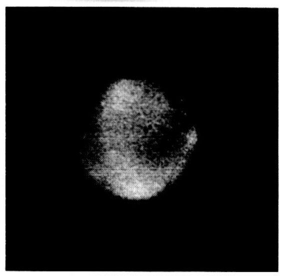
65 04 16 CG
CM 63° AG114
S MD 28 June



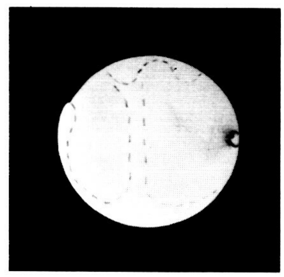
65 04 20 V
CM 23° AG126
M MD 30 June



65 04 16 V
CM 56° AG112
M MD 28 June

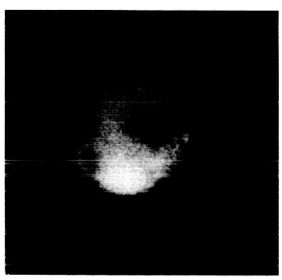


65 04 16 CB
CM 63° AG114
S MD 28 June

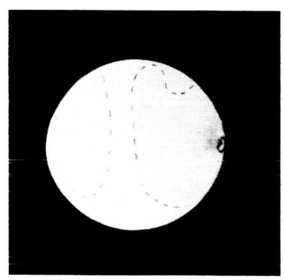


65 04 19 B
CM 10° AG124
D MD 30 June

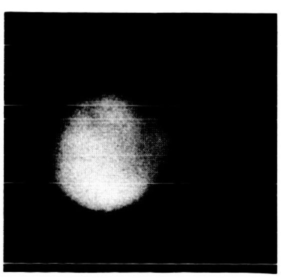
65 04 16 I
CM 34° AG108
D MD 18 June



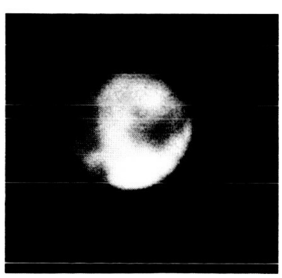
65 04 16 CI
CM 44° AG109
M MD 28 June



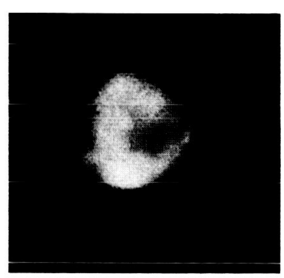
65 04 17 B
CM 35° AG116
D MD 29 June



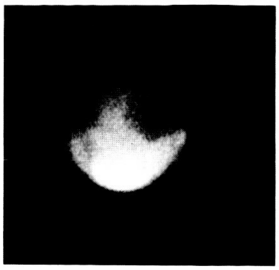
65 04 01 O
CM 200° AG106
M MD 21 June



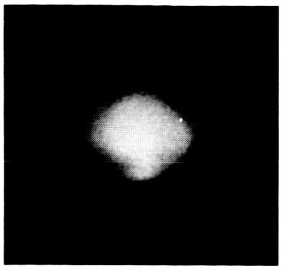
65 04 16 R
CM 58° AG113
M MD 28 June



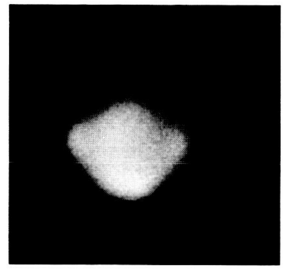
65 04 16 CI
CM 63° AG114
M MD 28 June



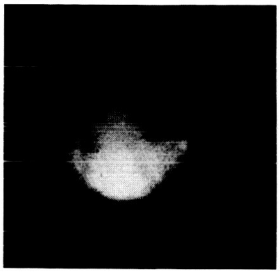
65 04 20 CI
CM 39° AG131
M MD 30 June



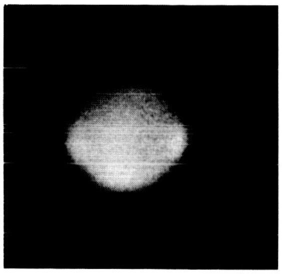
65 04 23 R
CM 350° AG140
S MD 2 July



65 04 27 V
CM 315° AG152
M MD 4 July

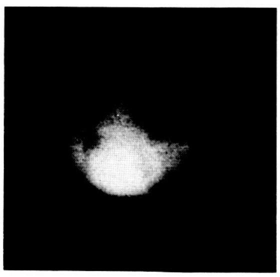


65 04 20 CI
CM 24° AG127
M MD 30 June

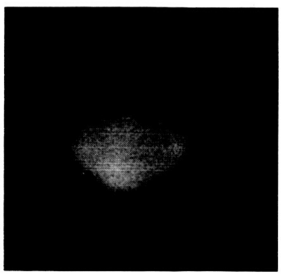


65 04 23 B
CM 355° AG142
S MD 2 July

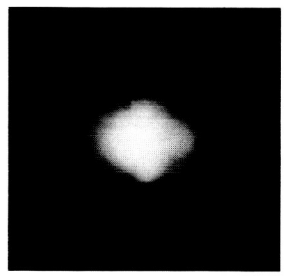
65 04 27 I
CM 300° AG153
D MD 4 July



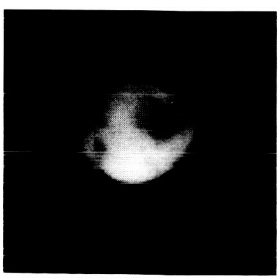
65 04 20 CR
CM 24° AG127
S MD 30 June



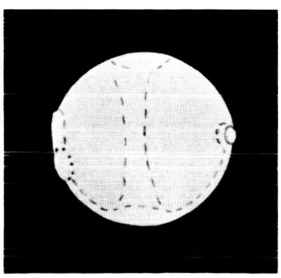
65 04 23 V
CM 357° AG143
S MD 2 July



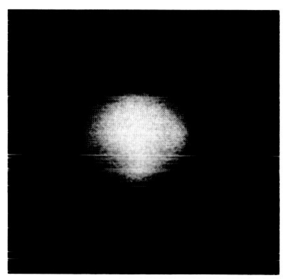
65 04 24 R
CM 338° 4130
M MD 2 July



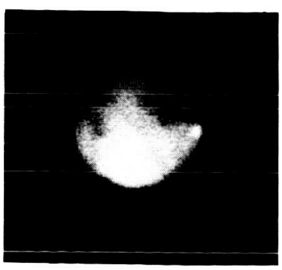
65 04 20 O
CM 46° AG132
M MD 30 June



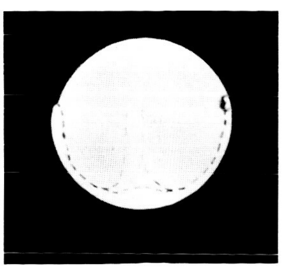
65 04 23 B
CM 350° AG144
D MD 2 July



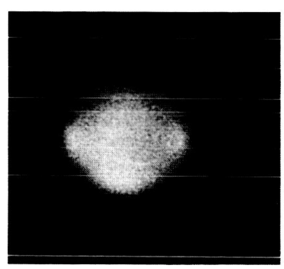
65 04 24 O
CM 338° AG147
S MD 2 July



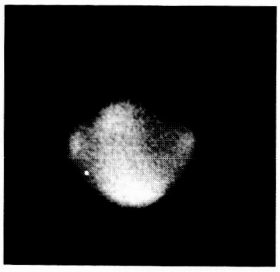
65 04 20 CG
CM 24° AG127
S MD 30 June



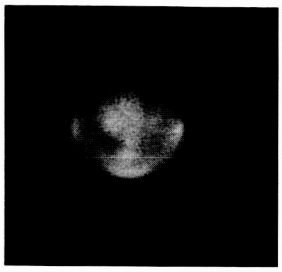
65 04 21 B
CM 05° AG136
D MD 1 July



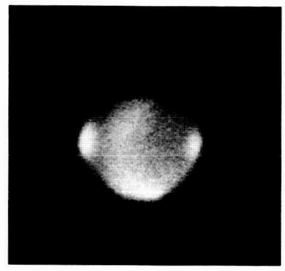
65 04 24 B
CM 331° AG145
S MD 2 July



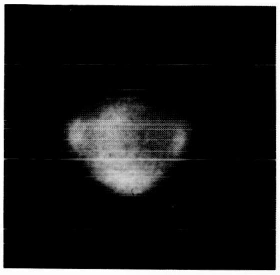
65 04 28 CB
CM 301° AG155
S MD 4 July



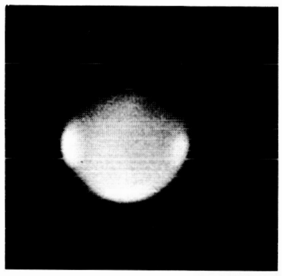
65 04 29 G
CM 329° AG161
S MD 4 July



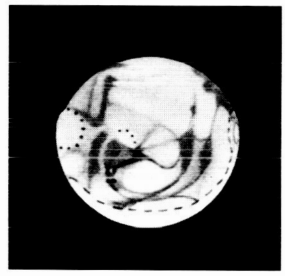
65 04 30 V
CM 315° AG168
S MD 5 July



65 04 28 V
CM 311° AG157
M MD 4 July

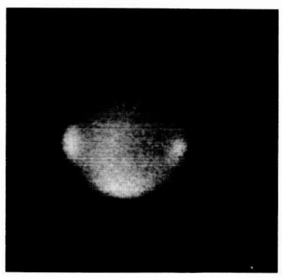


65 04 29 B
CM 331° AG162
S MD 4 July



65 04 30 I
CM 317° AG165
D MD 5 July

65 04 27 R
CM 301° 4142
M MD 4 July



65 04 29 V
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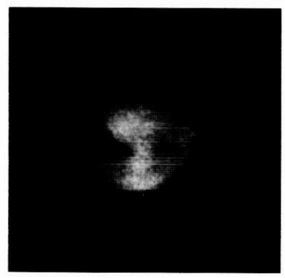
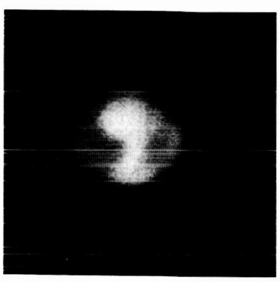
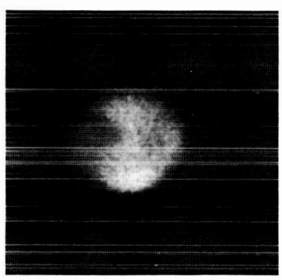
S MD 4 July



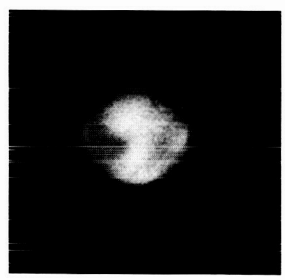
65 04 29 CI
CM 324° AG159
M MD 4 July



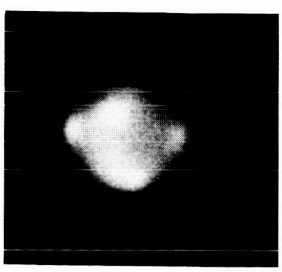
65 04 27 O
CM 311° 4143
M MD 4 July



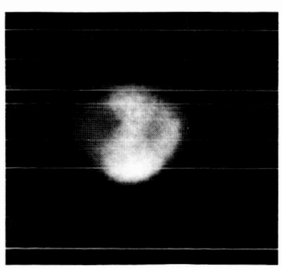
65 04 28 R
CM 292° 4149
S MD 4 July



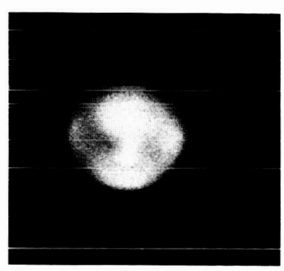
65 04 29 CR
CM 324° AG159
S MD 4 July



65 04 27 B
CM 311° AG150
M MD 4 July

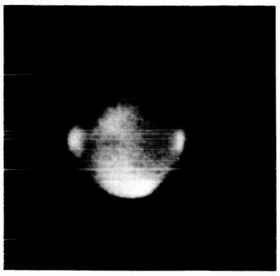


65 04 28 O
CM 289° 4148
S MD 4 July

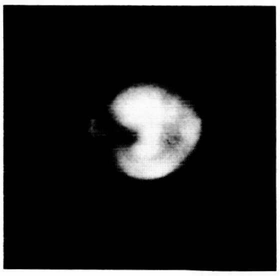


65 04 29 O
CM 319° AG158
S MD 4 July

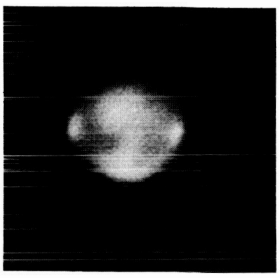
65 04 30 CG
CM 307° AG166
S MD 5 July



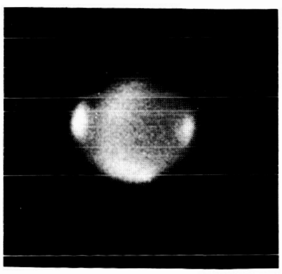
65 04 30 CB
CM 307° AG166
S MD 5 July



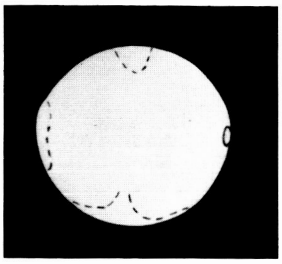
65 04 30 R
CM 319° AG170
S MD 5 July



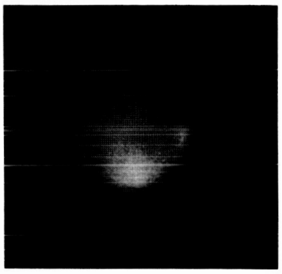
65 04 30 G
CM 322° AG171
S MD 5 July



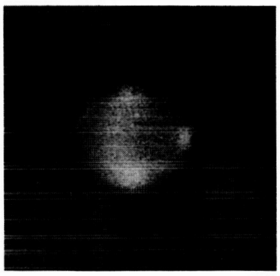
65 04 30 B
CM 312° AG167
S MD 5 July



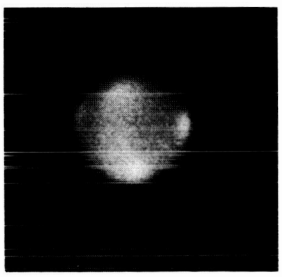
65 05 07 B
CM 254° AG182
D MD 8 July



65 05 01 G
CM 283° AG172
S MD 5 July

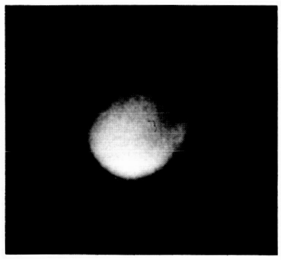


65 04 01 B
CM 288° AG173
S MD 5 July

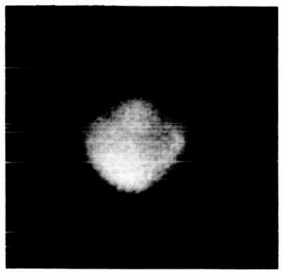


65 05 01 V
CM 291° AG174
S MD 5 July

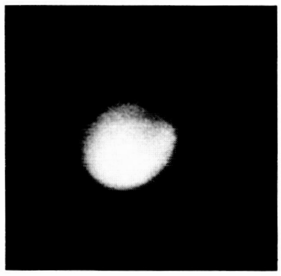
65 04 30 CR
CM 307° AG166
S MD 5 July



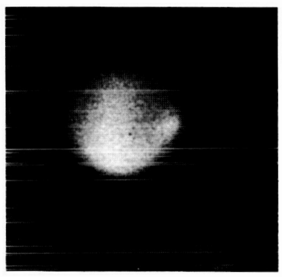
65 05 09 G
CM 191° 4158
M MD 9 July



65 05 09 V
CM 194° 4160
S MD 9 July



65 05 07 O
CM 259° AG185
S MD 8 July



65 05 07 B
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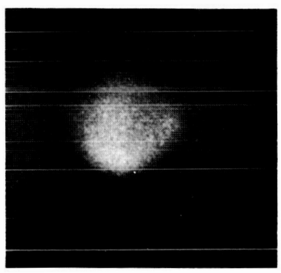
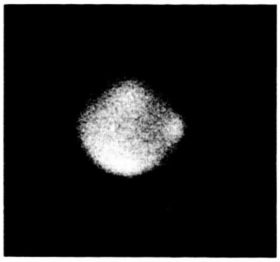


65 05 07 V
CM 254° AG184
S MD 8 July



65 05 10 B
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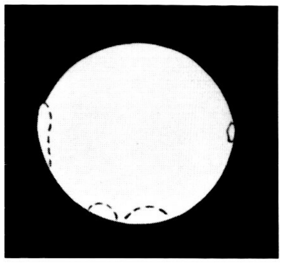
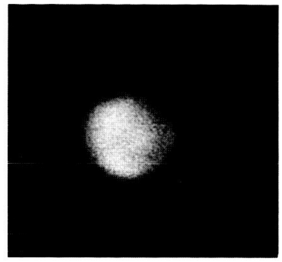
S MD 10 July



65 05 17 B
CM 102° 4177
D MD 13 July



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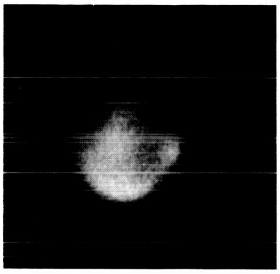

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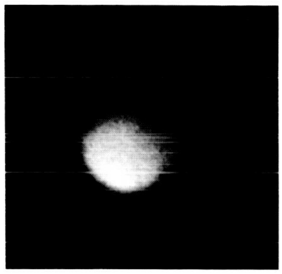

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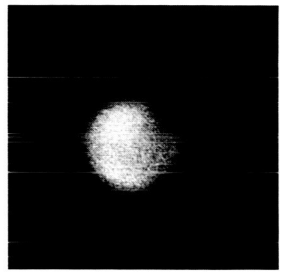

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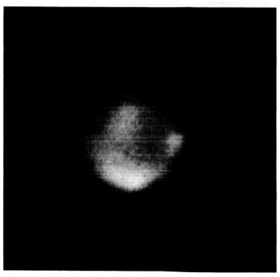

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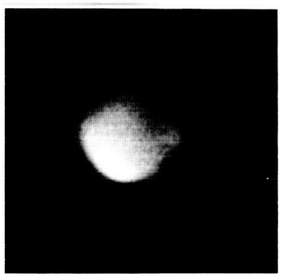

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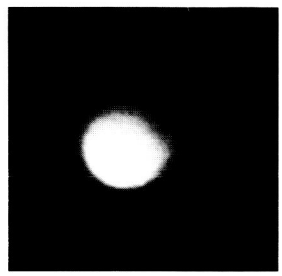

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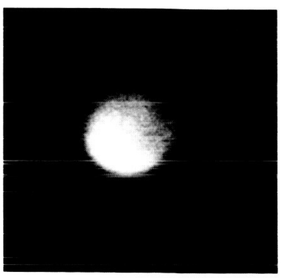

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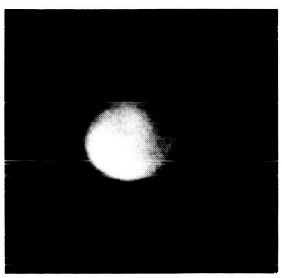

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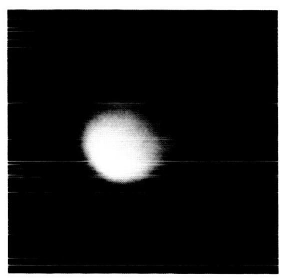

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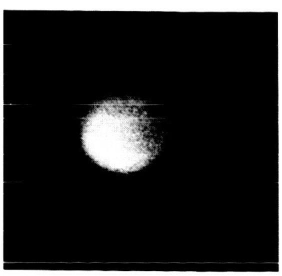

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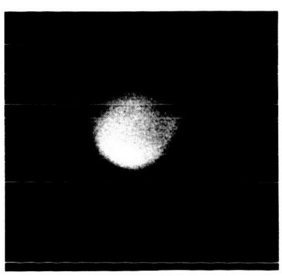

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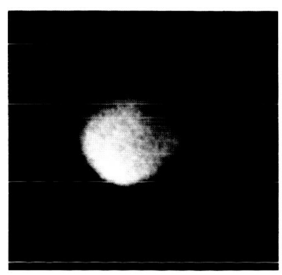

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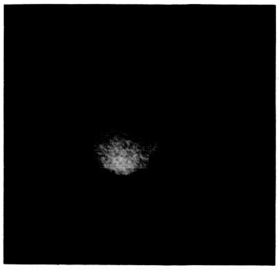

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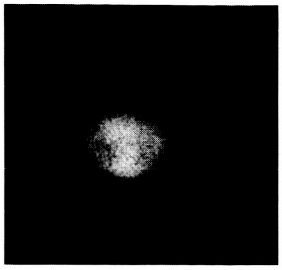

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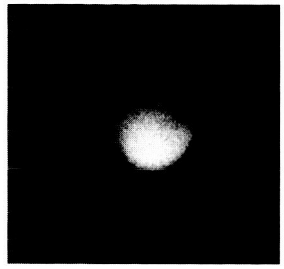

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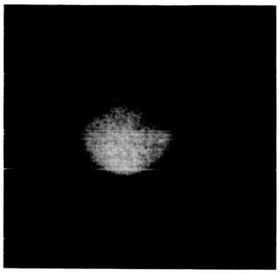

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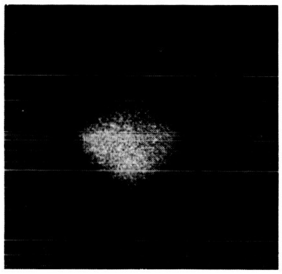

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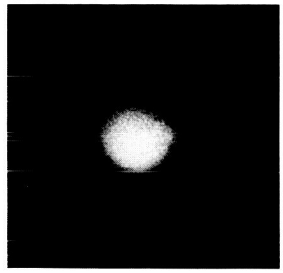
S MD 21 July



65 06 10 G
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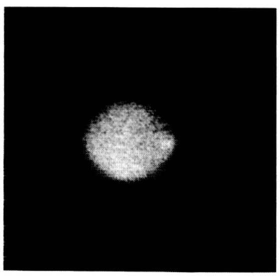

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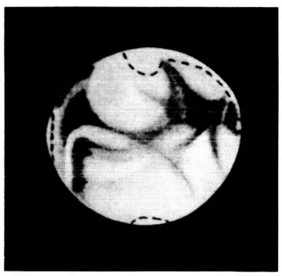

65 05 30 I
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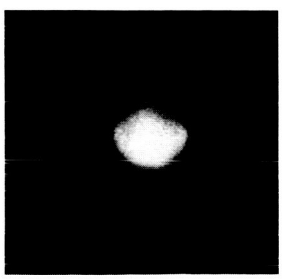
D MD 19 July

65 06 10 B
CM 251° 4211
S MD 25 July

65 05 28 I
CM 13° AG187
D MD 18 July



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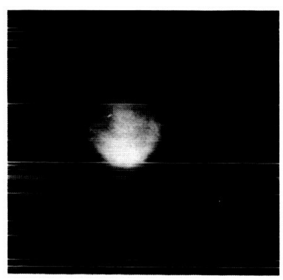

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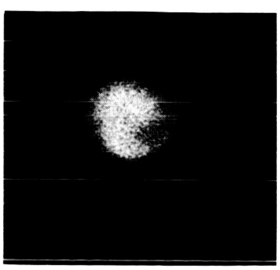

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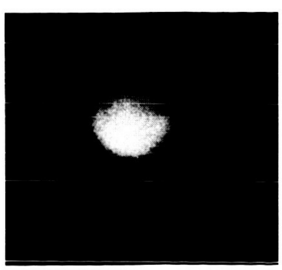

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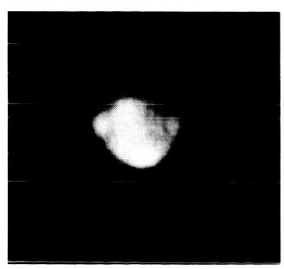

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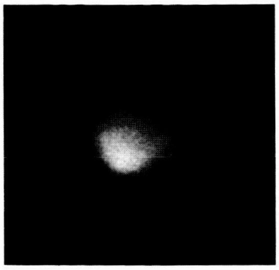

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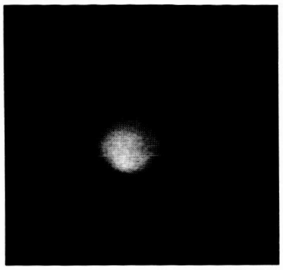

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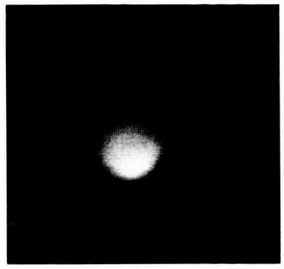

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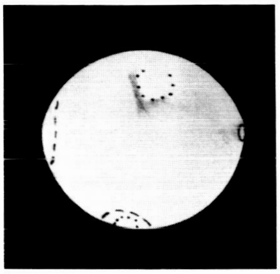

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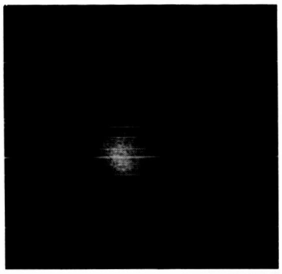
D MD 29 July



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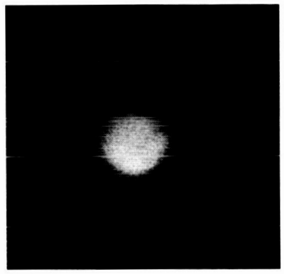

65 07 02 B
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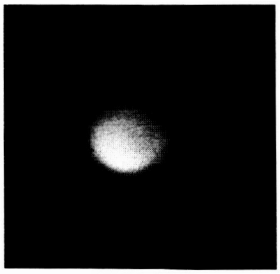

65 06 15 O
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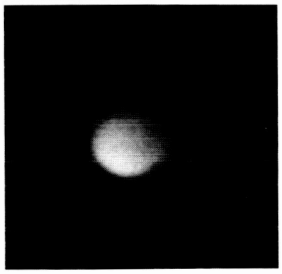

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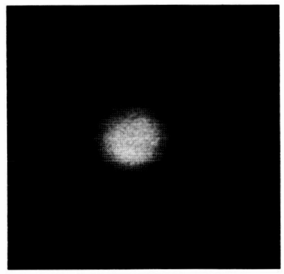

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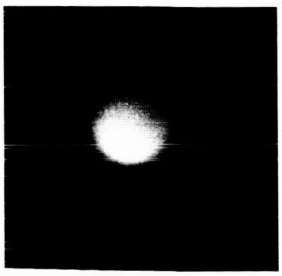

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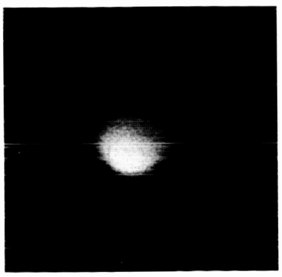

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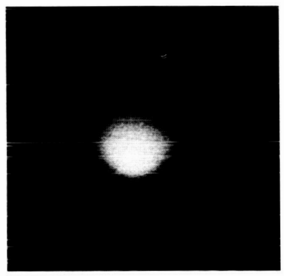

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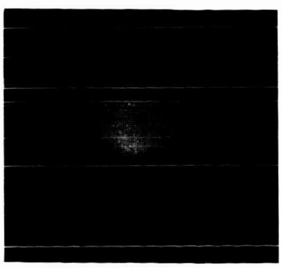

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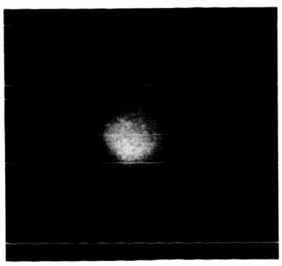

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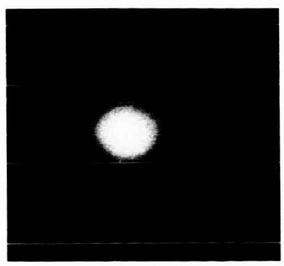

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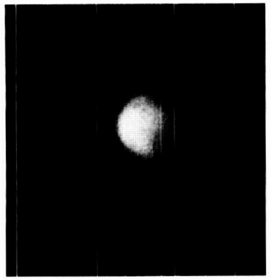

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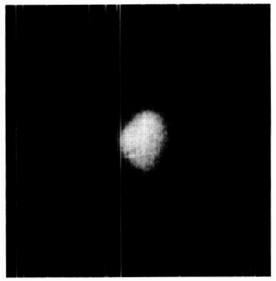

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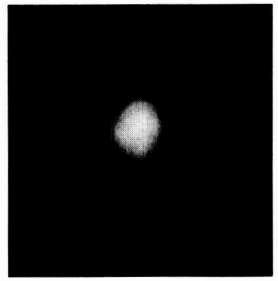

65 07 08 O
CM 331° 4224
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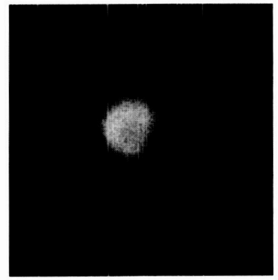

65 07 13 V
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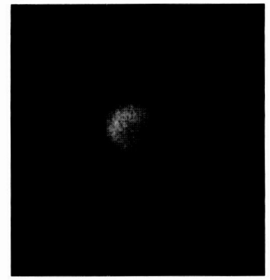

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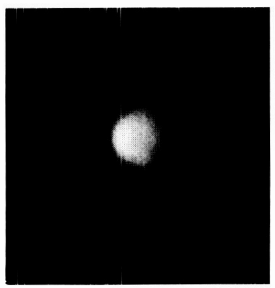

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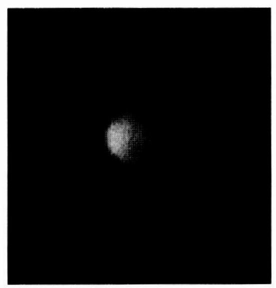

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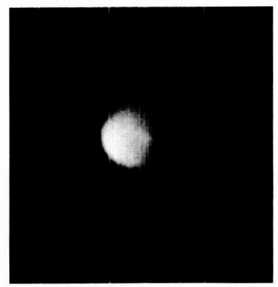

65 07 13 CI
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M MD 11 Aug.

# XII. *MARINER IV* PHOTOGRAPHIC DATA

The *Mariner IV* spacecraft's television camera recorded on tape, for playback to Earth space communication stations, a 21-picture sequence of the Martian surface on July 15, 1965, UT. The Martian date was 12 August, indicating a summer season in the northern hemisphere and a winter season in the south. The total area photographed was about 600,000 square miles, or approximately 1% of the total Martian surface. The camera scanned from north to south, recording pairs of overlapping pictures in a red-green, green-red filter sequence. The picture sequence began at $00^h18^m33^s$ UT. The first TV picture showed the limb of Mars against the black background of space with a slant range of 10,500 miles. The last picture recorded prior to reaching the evening terminator was Number 19, which had a slant range of about 7,500 miles. The TV pictures and the planetary science data were transmitted to Earth over distances ranging from 134 to 150 million miles.

The TV photographs were obtained with a 1.62-in. Cassegrain $f/8$ telescope. Exposures of 1/5 sec were made by a single rotating disk-shutter with four openings containing either a green Schott filter combination (BG-18, OG-4) or an orange Schott filter (OG-3), with approximately 24 sec between each exposure. The pictures were formed on a 200-line vidicon tube, with each line containing 200 elements and each element graded into 64 shades from white to black; which is about 250,000 bits of information per photograph. The *Mariner* photographs were taken in pairs with a partial overlap so that a comparison could be made of the same area in green and orange light.

A 1965 photovisual map of Martian surface features in the vicinity of the *Mariner IV* scan region was drawn from 22 separate photographs and 10 identification drawings obtained during the Martian summer season. The map accommodates only the first eleven *Mariner IV* picture areas because the planetary axial tilt was $+21°$ through $+24°$, which prevented accurate southern hemisphere measurements above $-35°$ latitude. The map was constructed from reticle comparator length and angular measurements of photographic detail and proportionally transferred to the map shown in Fig. 34. It is orientated with south at the top, north at the bottom, and the longitudes are presented in the normal astronomical direction in order to avoid confusion with existing maps of Mars.

The *Mariner* picture center and corner positions used were updated to October 12, 1965 data (Ref. 16). The subsolar point during the time of *Mariner* photography lies just east of the scan track at 173° long., $+15°$ lat., and it is indicated by an oval.

The 1965 photovisual map and 16 *Mariner IV* pictures (Figs. 35–42) with related data are presented for the reader's use and interpretation. The *Mariner IV* pictures are also presented in the astronomical sense, with south at the top, north at the bottom, east to the left, and west on the right of the frame. The recorded surface features are similar in many respects to those of the Moon; i.e., rille-like crater chains, rift valleys, hexagonal-shaped craters, flat-floored craters, inverted cone-shaped craters, a spectrum of crater sizes, central crater peaks, small craters on large crater rims, domes, and a dome with a caldera. Also, white frost patches, cloud shadows, and canal-like structure can possibly be interpreted to exist on the Martian surface relief. The surface area sampling was too small and the photographic distance too great for the detection of life as we know it on the Earth.

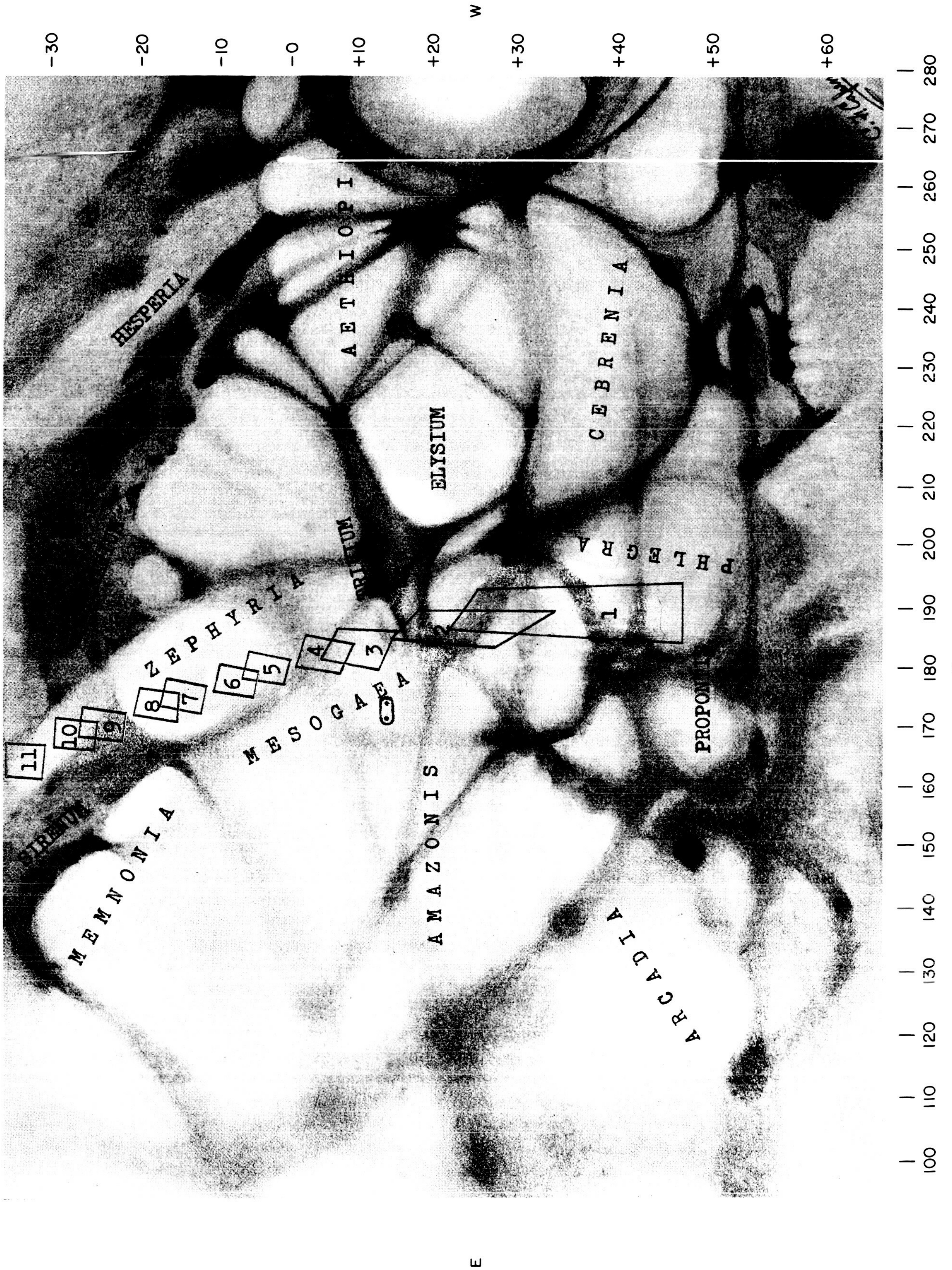
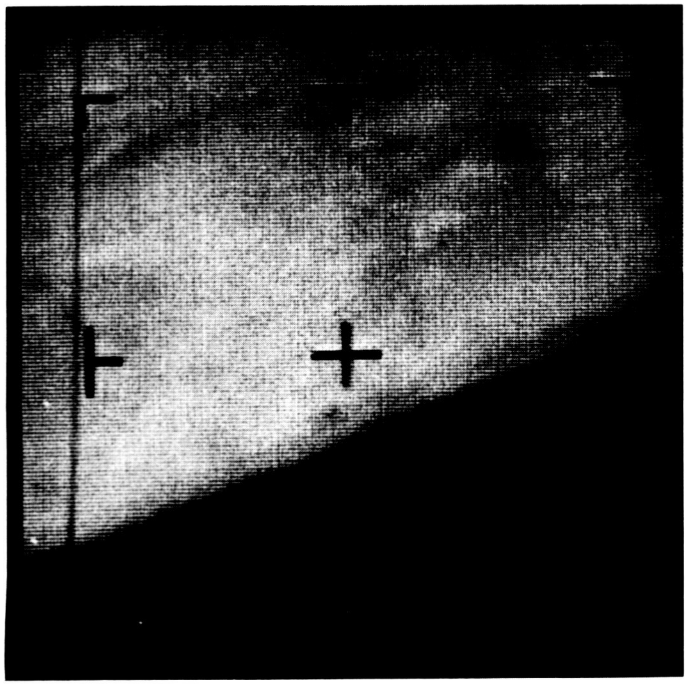
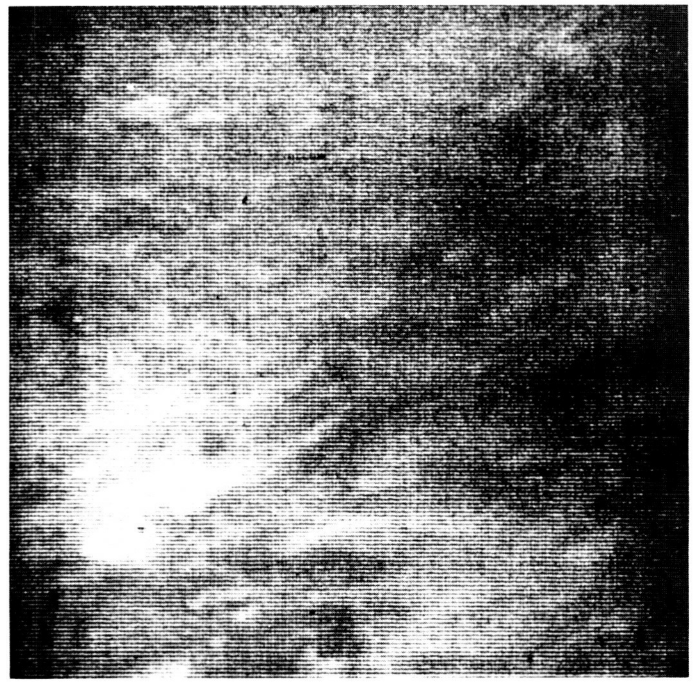



**Fig. 34. A 1965 photovisual map of the *Mariner IV* scan region**

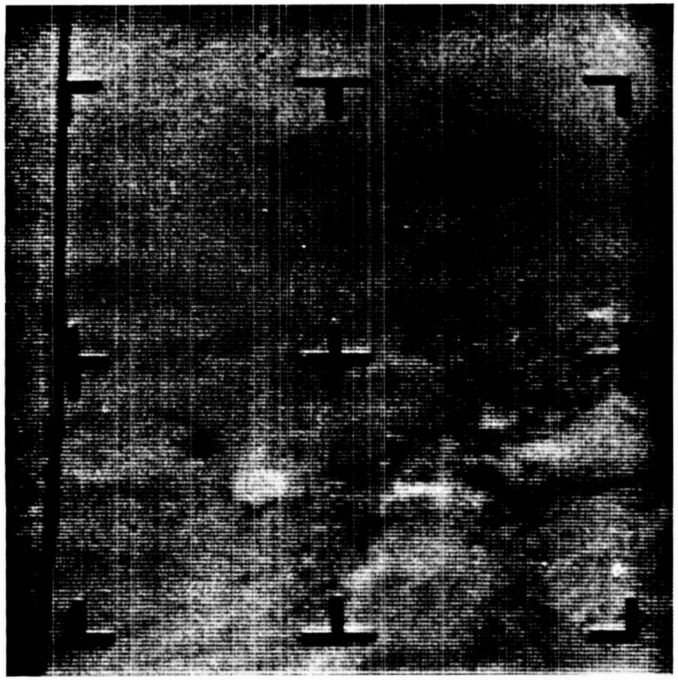



*Mariner IV*—Picture 1.
Sun zenith angle is 25° from the southeast.
Time: $00^h18^m33^s$; July 15, 1965 UT.
Slant range: 10,500 miles.
Dimensions: 410 miles along limb; 800 miles from limb to south edge.
Location ca.: 188° long.; +33° lat.
Filter: Orange (OG-3).
Area description: The bright Phlegra region between the Trivium and the Propontis. The frame crosses the Hades canal. A possible cloud or haze is recorded above the NE horizon. Dark and light areas are recorded.

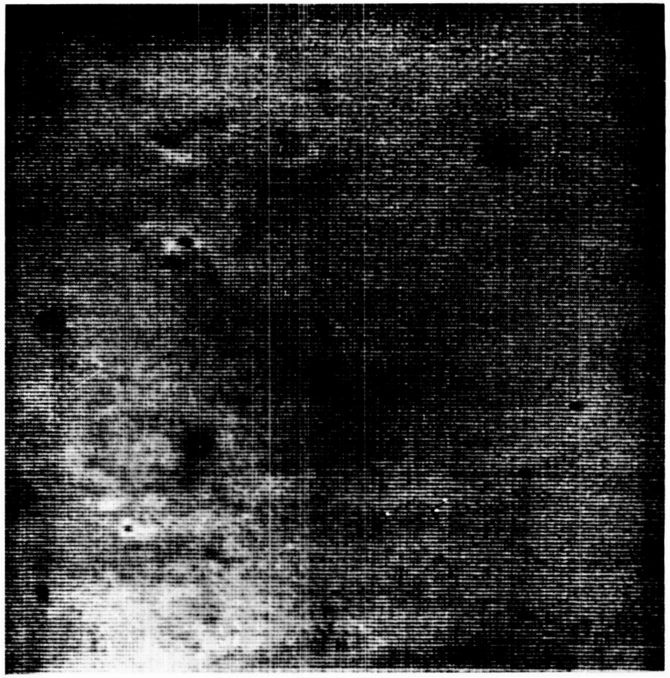



*Mariner IV*—Picture 2.
Sun zenith angle is 20° from the southeast.
Time: $00^h19^m21^s$; July 15, 1965 UT.
Slant range: 10,100 miles.
Dimensions: E–W 290 miles; N–S 530 miles.
Location ca.: 186° long.; +23° lat.
Filter: Green (BG-18 and OG-4).
Area description: Western Amazonis desert just NE of the Trivium. The frame crosses the Erebus canal. The picture overlaps Picture 1 (refer to Fig. 34). Dark and light contrast areas, and craters in the SE sector are recorded in this frame.

**Fig. 35. *Mariner IV*—Pictures 1 and 2**



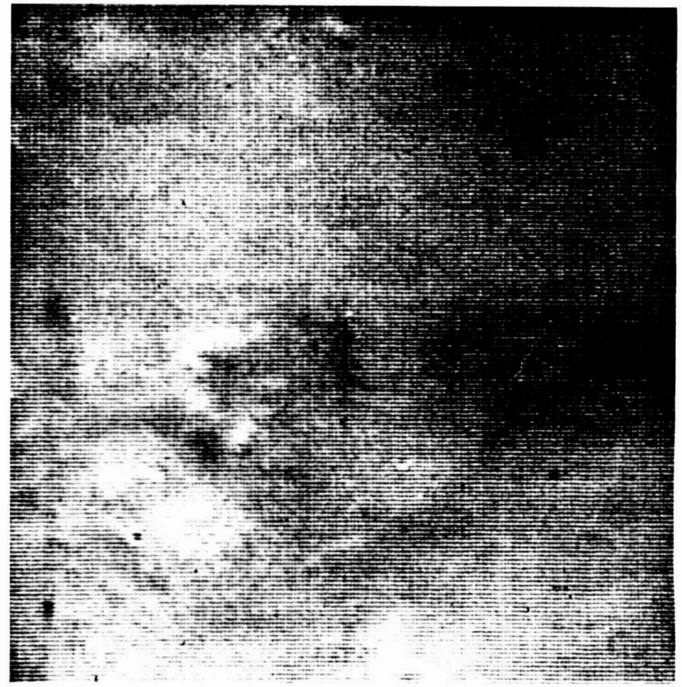

*Mariner IV*—Picture 3.
Sun zenith angle is 14° from the east.
Time: $00^h20^m57^s$; July 15, 1965 UT.
Slant range: 9,500 miles.
Dimensions: E–W 220 miles; N–S 310 miles.
Location ca.: 183° long.; +10° lat.
Filter: Green.
Area description: Amazonis–Mesogaea ocher desert region SE of the Trivium. The south edge of frame lies on the Tartarus canal. Several hexagonal craters and rilles are recorded.




*Mariner IV*—Picture 4.
Sun zenith angle is 14° from the northeast.
Time: $00^h21^m45^s$; July 15, 1965 UT.
Slant range: 9,300 miles.
Dimensions: E–W 210 miles; N–S 270 miles.
Location ca.: 182 long.; +05 lat.
Filter: Orange.
Area description: Mesogaea desert. Middle frame over the Tartarus and Saus–Avernus canals. This picture overlaps Picture 3. Light and dark contrasts and smaller craters are present in the Aquae Fons area. Possible canal structure is indicated radiating from the center of this frame.

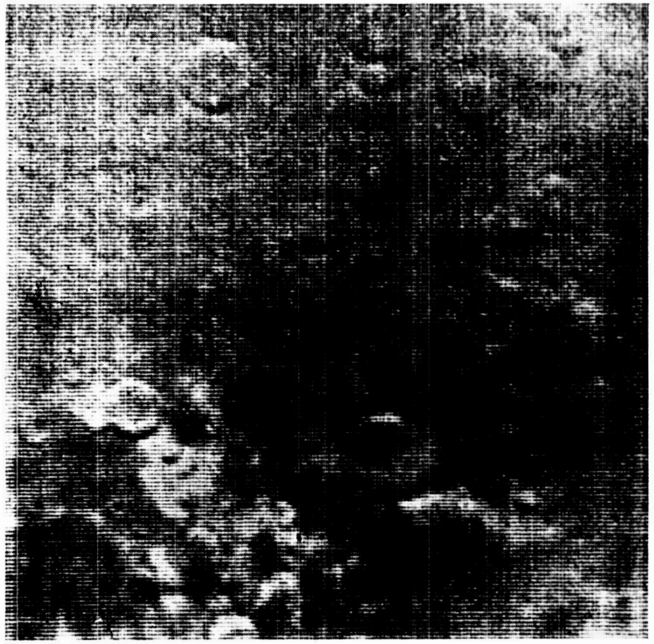
**Fig. 36. *Mariner IV*—Pictures 3 and 4**


*Mariner IV*—Picture 5.
Sun zenith angle is 19° from the north.
Time: $00^h23^m21^s$; July 15, 1965 UT.
Slant range: 8,900 miles.
Dimensions: E–W 190 miles; N–S 220 miles.
Location ca.: 179° long.; −03° lat.
Filter: Orange.
Area description: Over the Zephyria desert just above the Martian equator. Many small craters and a crater chain rille are noted.




*Mariner IV*—Picture 6.
Sun zenith angle is 22° from the north at the bottom of the frame.
Time: $00^h24^m09^s$; July 15, 1965 UT.
Slant range: 8,700 miles.
Dimensions: E–W 190 miles; N–S 200 miles.
Location ca.: 178° long.; −07° lat.
Filter: Green.
Area description: Over the Zephyria ocher desert. Ill-defined bright rimmed craters and a dark area on the west side of the frame. This picture overlaps Picture 5.

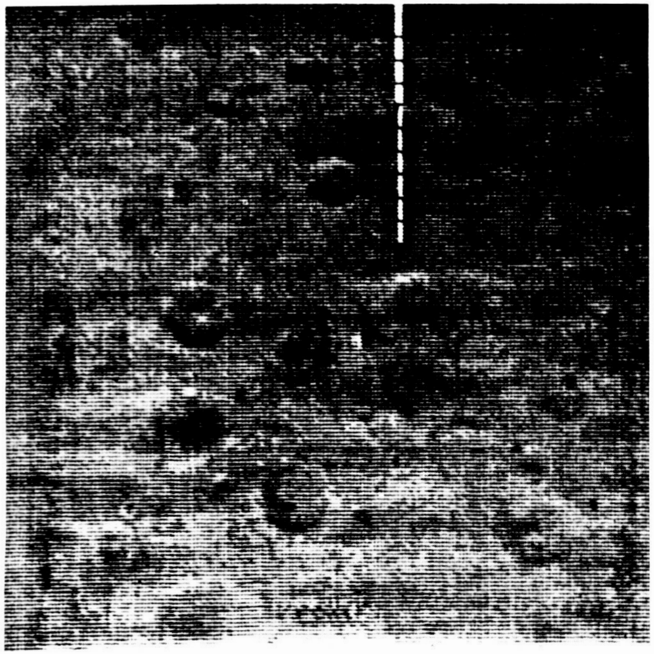
**Fig. 37. *Mariner IV*—Pictures 5 and 6**



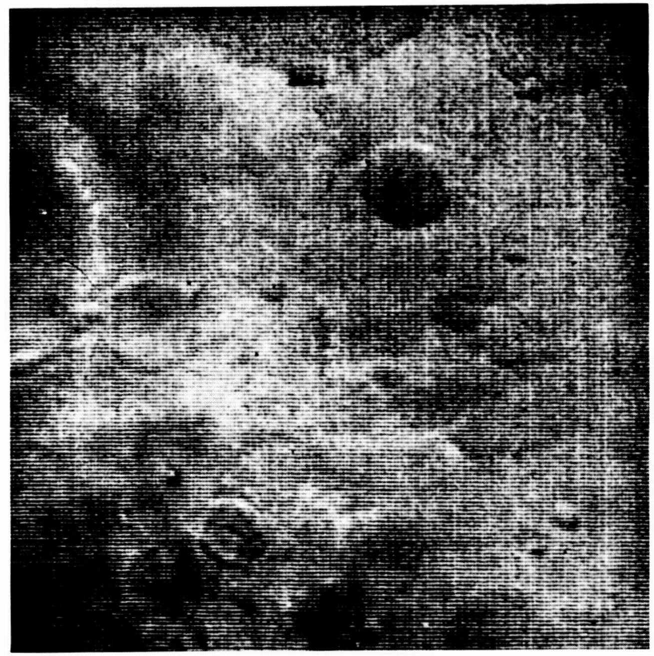

*Mariner IV*—Picture 7.
Sun zenith angle is 29° from the north.
Time: $00^h25^m45^s$; July 15, 1965 UT.
Slant range: 8,400 miles.
Dimensions: E–W 180 miles; N–S 180 miles.
Location ca.: 175° long.; −14° lat.
Filter: Green.
Area description: Over the southeastern Zephyria desert. Many hexagonal flat-floored craters, smaller inverted cone-shaped craters, and rilles are present in the picture.


*Mariner IV*—Picture 8.
Sun zenith angle is 32° from the north.
Time: $00^h26^m33^s$; July 15, 1965 UT.
Slant range: 8,300 miles.
Dimensions: E–W 180 miles; N–S 170 miles.
Location ca.: 173° long.; −18° lat.
Filter: Orange.
Area description: Over southeastern Zephyria desert next to the Mare Sirenum border. Three large, flat-floored hexagonal craters, small cone-shaped craters, and possible rille structure. This picture overlaps Picture 7.

**Fig. 38. *Mariner IV*—Pictures 7 and 8**

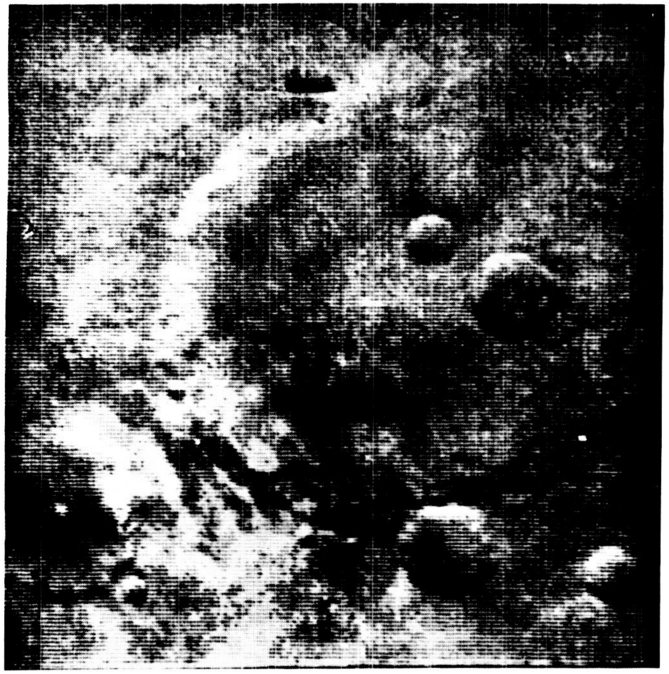



*Mariner IV*—Picture 9.
Sun zenith angle is 38° from the north.
Time: $00^h28^m09^s$; July 15, 1965 UT.
Slant range: 8,100 miles.
Dimensions: E–W 170 miles; N–S 160 miles.
Location ca.: 170° long.; −24° lat.
Filter: Orange.
Area description: Partly over the dark Mare Sirenum and the lighter Atlantis area. The craters are more numerous, and one flat-floored crater is seen with a central peak. Two crater pairs appear to be connected by rift valleys.

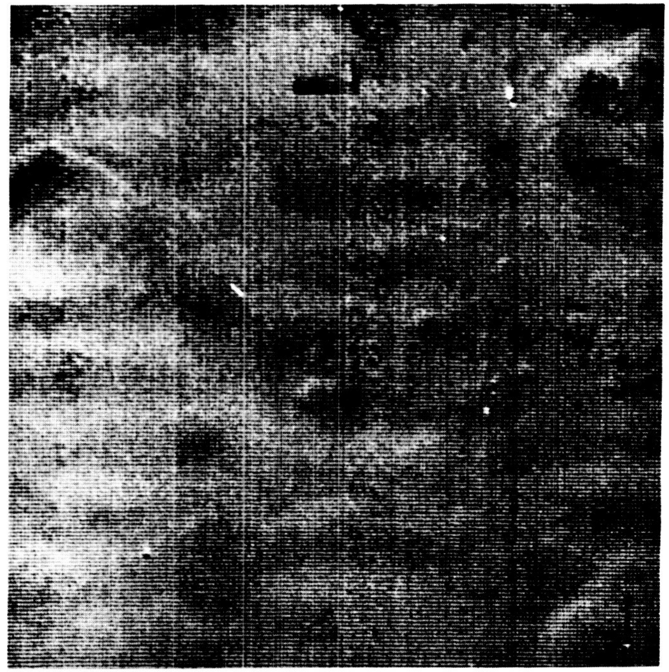



*Mariner IV*—Picture 10.
Sun zenith angle is 41° from the north.
Time: $00^h28^m57^s$; July 15, 1965 UT.
Slant range: 8,000 miles.
Dimensions: E–W 170 miles; N–S 160 miles.
Location ca.: 168° long.; −27° lat.
Filter: Green.
Area description: Over the southern border of the Mare Sirenum and mid-Atlantis region. Large craters with diameters of 30 to 70 miles are recorded in this frame. Crater peaks and cone-shaped craters are still in evidence. Small craters on larger crater rims are recorded. This picture overlaps Picture 9.

**Fig. 39. *Mariner IV*—Pictures 9 and 10**

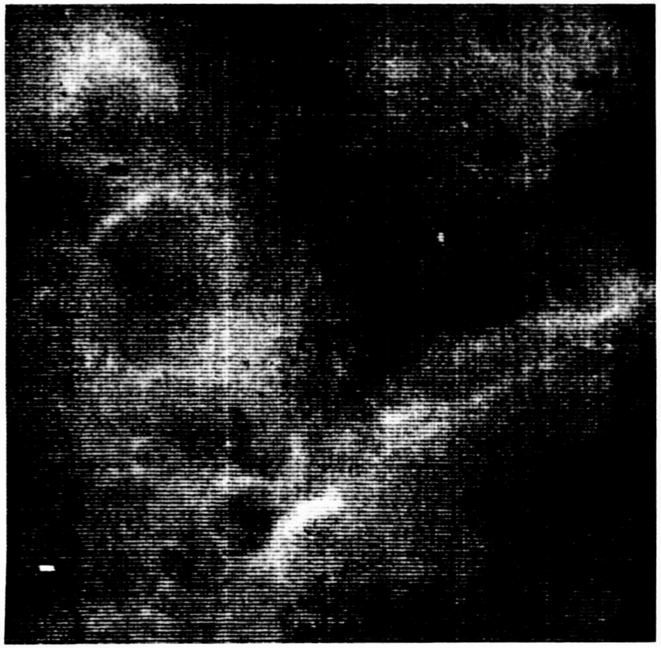



*Mariner IV*—Picture 11.
Sun zenith angle is 47° from the north.
Time: $00^h30^m33^s$; July 15, 1965 UT.
Slant range: 7,800 miles.
Dimensions: E–W 170 miles; N–S 150 miles.
Location ca.: 163° long.; −32° lat.
Filter: Green.
Area description: Over the light area Atlantis and northern edge of the dark Mare Cimmerium. This frame (the finest frame of the series) shows craters with diameters from 3 miles to about 100 miles. Many rilles with crater chains, large flat-floored craters, small cone-shaped craters, small mountain-type crags, a caldera-type dome, a crater with a central peak, and a possible rift valley are recorded in this picture.




*Mariner IV*—Picture 12.
Sun zenith angle is 50° from the north.
Time: $00^h31^m21^s$; July 15, 1965 UT.
Slant range: 7,700 miles.
Dimensions: E–W 170 miles; N–S 150 miles.
Location ca.: 161° long.; −35° lat.
Filter: Orange.
Area description: Covers a small southern section of the light area Atlantis and a northeastern part of the Mare Cimmerium. Various sizes and types of craters are vaguely recorded. This picture overlaps Picture 11.

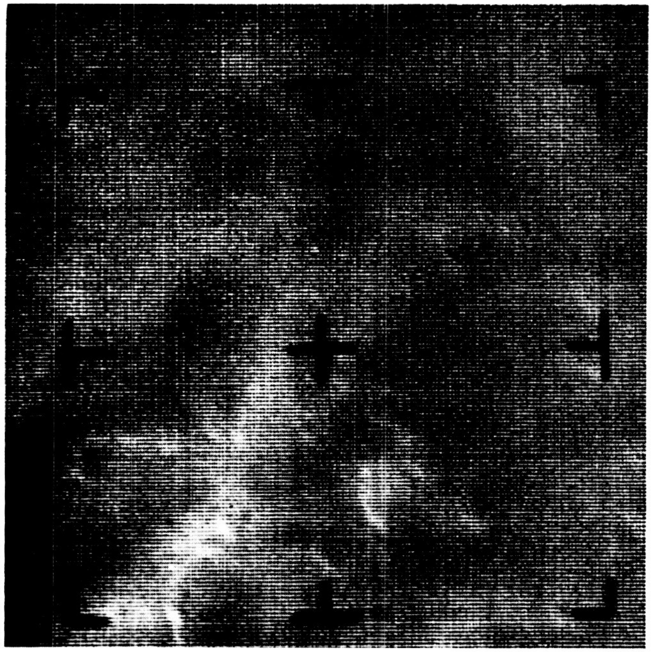
**Fig. 40. *Mariner IV*—Pictures 11 and 12**




*Mariner IV*—Picture 13.
Sun zenith angle is 57° from the north.
Time: $00^h32^m57^s$; July 15, 1965 UT.
Slant range: 7,600 miles.
Dimensions: E–W 170 miles; N–S 140 miles.
Location ca.: 155° long.; −40° lat.
Filter: Orange.
Area description: In the vicinity of southeastern Mare Cimmerium, Simois, and northwestern Phaethontis. Craters with bright rims are noted.


*Mariner IV*—Picture 14.
Sun zenith angle is 60° from the north.
Time: $00^h33^m45^s$; July 15, 1965 UT.
Slant range: 7,600 miles.
Dimensions: E–W 170 miles; N–S 140 miles.
Location ca.: 151° long.; −42° lat.
Filter: Green.
Area description: Over the light area of northwestern Phaethontis. Numerous crater sizes with partial bright rims. The Phaethontis is located in a relatively high southern latitude. The Martian season in the southern hemisphere is midwinter. This picture overlaps Picture 13.

**Fig. 41. *Mariner IV*—Pictures 13 and 14**




*Mariner IV*—Picture 15.

Sun zenith angle is 66° from the northwest.

Time: $00^h35^m21^s$; July 15, 1965 UT.

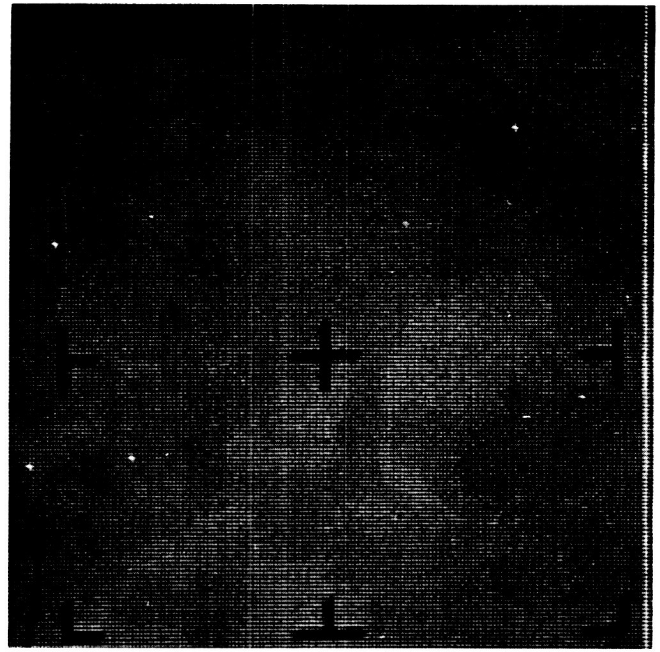
Slant range: 7,500 miles.

Dimensions: E–W 180 miles; N–S 140 miles.

Location ca.: 143° long.; −46° lat.

Filter: Green.

Area description: Over the middle section of the light area Phaethontis. The Phaethontis area is located in a relatively high southern latitude. Light and dark areas and several bright rim craters are present in the picture.




*Mariner IV*—Picture 16.

Sun zenith angle is 69° from the northwest.

Time: $00^h36^m09^s$; July 15, 1965 UT.

Slant range: 7,500 miles.

Dimensions: E–W 190 miles; N–S 140 miles.

Location ca.: 139° long.; −48° lat.

Filter: Orange.

Area description: Over the southeastern Phaethontis area. The picture definition has decreased in this frame. Vague craters can possibly be noted. This picture is about 35° from the evening terminator, and it overlaps Picture 15.

**Fig. 42. *Mariner IV*—Pictures 15 and 16**

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# APPENDIX A

## The Mars 1964–1965 Apparition Observation Log

The columns list the following information for reference to the Daily Observation Report and the Mars Atlas:

1. The Table Mountain observation log number is given unless the number is prefixed by letters, in which case the observation was performed at another observatory, i.e., the Kitt Peak National Observatory 84-inch reflector (KP), or the Astrogeology Gilbert Observatory–USGS, 30-inch reflector (AG).
2. Terrestrial Universal Time date.
3. Universal Time (UT) of the beginning of the observation.
4. Central Meridian (CM) during the time of observation.
5. Declination of the Earth in degrees as viewed from Mars, which defines the axial tilt relative to the Earth.
6. Phase of the terminator in areocentric degrees.
7. The apparent disk diameter in seconds of subtended arc.
8. Martian Date (MD). The local Martian date is determined from the planetocentric longitude of the Sun as measured from the vernal equinox, which occurs when the subsolar point coincides with the Martian equator and the planetocentric longitude of the Sun equals zero degree. The summer solstice occurs at 90°. The autumnal equinox equals 180°. The winter solstice equals 270°.
9. Planetocentric longitude of the Sun ($L_S$) in degrees.
10. The type of observation indicates either a visual observation, the photographic pass-band color, integrated light, or color photography.

| Log No. | TD (UT) | UT | CM, ° | Declination ⊕ (tilt), ° | Terminator, ° | Diameter, " | MD | $L_s$, ° | Observation type |
|---|---|---|---|---|---|---|---|---|---|
| | 1964 | | | | | | | | |
| 3016 | Sept. 11 | 1248 | 19 | +11.9 | 29.8 | 4.7 | 19 Mar. | 359 | Visual |
| 3029 | 15 | 1137 | 324 | 12.8 | 30.1 | 4.7 | 21 | 1 | Orange |
| 3030 | 15 | 1149 | 326 | 12.8 | 30.1 | 4.7 | 21 | 1 | Blue |
| 3059 | 17 | 1153 | 307 | 13.2 | 30.6 | 4.8 | 22 | 2 | Visual |
| 3076 | 19 | 1226 | 297 | 13.2 | 30.6 | 4.8 | 23 | 3 | Visual |
| 3117 | 26 | 1233 | 230 | 15.2 | 30.6 | 4.9 | 27 | 6 | Visual |
| 3134 | 28 | 1215 | 207 | 15.6 | 32.1 | 5.0 | 28 | 7 | Visual |
| 3150 | 29 | 1302 | 207 | 15.6 | 32.1 | 5.0 | 28 | 8 | Color |
| 3151 | 29 | 1311 | 210 | 15.6 | 32.1 | 5.0 | 28 | 8 | Visual |
| 3164 | 30 | 1156 | 183 | 15.9 | 32.1 | 5.0 | 29 | 8 | Visual |
| 3191 | Oct. 1 | 1155 | 174 | 15.9 | 32.1 | 5.0 | 29 | 9 | Visual |
| 3192 | 1 | 1228 | 181 | 15.9 | 32.1 | 5.0 | 29 | 9 | Blue |
| 3193 | 1 | 1235 | 183 | 15.9 | 32.1 | 5.0 | 29 | 9 | Orange |
| 3194 | 1 | 1242 | 183 | 15.9 | 32.1 | 5.0 | 29 | 9 | Color |
| 3231 | 3 | 1256 | 169 | 16.3 | 32.5 | 5.0 | 30 | 10 | Visual |
| 3232 | 3 | 1322 | 174 | 16.3 | 32.5 | 5.0 | 30 | 10 | Integrated |
| 3248 | 4 | 1246 | 157 | 16.7 | 32.5 | 5.1 | 31 | 10 | Color |
| 3249 | 4 | 1304 | 159 | 16.7 | 32.5 | 5.1 | 31 | 10 | Visual |
| 3258 | 5 | 1227 | 142 | 16.7 | 32.5 | 5.1 | 31 | 11 | Visual |
| 3269 | 6 | 1225 | 132 | 17.6 | 32.5 | 5.1 | 31 | 11 | Visual |
| 3280 | 7 | 1228 | 123 | 17.6 | 32.5 | 5.1 | 1 Apr. | 12 | Visual |
| 3290 | 9 | 1247 | 108 | 17.6 | 33.2 | 5.1 | 2 | 13 | Visual |
| 3295 | 11 | 1254 | 89 | 17.7 | 33.2 | 5.2 | 3 | 14 | Visual |
| 3301 | 12 | 1236 | 77 | 18.0 | 33.2 | 5.2 | 3 | 14 | Visual |
| 3307 | 13 | 1240 | 67 | 18.0 | 33.2 | 5.2 | 3 | 15 | Visual |
| 3312 | 14 | 1103 | 33 | 18.0 | 33.2 | 5.3 | 4 | 15 | Visual |
| 3322 | 16 | 1300 | 43 | 18.6 | 34.0 | 5.3 | 5 | 16 | Visual |
| 3323 | 16 | 1317 | 48 | 18.6 | 34.0 | 5.3 | 5 | 16 | Blue |
| 3324 | 16 | 1327 | 50 | 18.6 | 34.0 | 5.3 | 5 | 16 | Orange |
| 3345 | 18 | 1205 | 11 | 18.6 | 34.0 | 5.4 | 6 | 17 | Visual |
| 3355 | 20 | 1217 | 354 | 19.2 | 34.0 | 5.4 | 7 | 18 | Visual |
| 3364 | 21 | 1300 | 355 | 19.2 | 34.0 | 5.4 | 7–8 | 18 | Visual |
| 3404 | 25 | 1330 | 323 | 19.7 | 34.0 | 5.5 | 10 | 20 | Visual |
| 3432 | Nov. 4 | 1222 | 209 | 20.6 | 35.2 | 5.8 | 14 | 25 | Visual |
| 3475 | 21 | 1226 | 48 | 22.0 | 36.6 | 6.4 | 22 | 33 | Visual |
| 3476 | 21 | 1226 | 48 | 22.0 | 36.6 | 6.4 | 22 | 33 | Blue |
| 3477 | 21 | 1238 | 51 | 22.0 | 36.6 | 6.4 | 22 | 33 | Orange |
| 3496 | 23 | 1341 | 46 | 22.0 | 36.6 | 6.5 | 23 | 34 | Blue |
| 3497 | 23 | 1347 | 48 | 22.0 | 36.6 | 6.5 | 23 | 34 | Visual |
| 3514 | 24 | 1258 | 27 | 22.0 | 36.6 | 6.5 | 24 | 34 | Visual |
| 3557 | 25 | 1200 | 2 | 22.0 | 36.6 | 6.6 | 24 | 34 | Orange |
| 3571 | Dec. 6 | 1210–1323 | 259–277 | 22.6 | 36.8 | 7.0 | 29 | 39 | Visual |
| 3572 | 6 | 1230 | 264 | 22.6 | 36.8 | 7.0 | 29 | 39 | Color |
| 3573 | 6 | 1246 | 269 | 22.6 | 36.8 | 7.0 | 29 | 39 | Integrated |
| 3574 | 6 | 1255 | 272 | 22.6 | 36.8 | 7.0 | 29 | 39 | Orange |
| 3575 | 6 | 1311 | 274 | 22.6 | 36.8 | 7.0 | 29 | 39 | Blue |
| 3576 | 6 | 1316 | 277 | 22.6 | 36.8 | 7.0 | 29 | 39 | Green |

| Log No. | TD (UT) | UT | CM, ° | Declination ⊕ (tilt), ° | Terminator, ° | Diameter, ″ | MD | $L_s$, ° | Observation type |
|---|---|---|---|---|---|---|---|---|---|
| 3579 | Dec. 7 | 1225 | 255 | 22.6 | 36.8 | 7.1 | 30 Apr. | 40 | Visual |
| 3580 | 8 | 1250 | 250 | 22.6 | 36.8 | 7.1 | 30 | 40 | Orange |
| 3581 | 8 | 1256 | 253 | 22.6 | 36.8 | 7.1 | 30 | 40 | Yellow-Green |
| 3599 | 10 | 1330 | 241 | 22.7 | 36.8 | 7.2 | 1 May | 41 | Visual |
| 3600 | 10 | 1355 | 248 | 22.7 | 36.8 | 7.2 | 1 | 41 | Blue |
| 3601 | 10 | 1406 | 251 | 22.7 | 36.8 | 7.2 | 1 | 41 | Green |
| 3602 | 10 | 1416 | 253 | 22.7 | 36.8 | 7.2 | 1 | 41 | Orange |
| 3620 | 14 | 1255 | 195 | 22.7 | 36.8 | 7.4 | 3 | 43 | Visual |
| 3621 | 14 | 1325 | 203 | 22.7 | 36.8 | 7.4 | 3 | 43 | Color |
| 3622 | 14 | 1334 | 203 | 22.7 | 36.8 | 7.4 | 3 | 43 | Orange |
| 3623 | 14 | 1345 | 208 | 22.7 | 36.8 | 7.4 | 3 | 43 | Blue |
| 3624 | 14 | 1358 | 210 | 22.7 | 36.8 | 7.4 | 3 | 43 | Green |
| 3637 | 15 | 1254–1415 | 183–205 | 22.8 | 36.8 | 7.5 | 3 | 43 | Visual |
| 3638 | 15 | 1305 | 188 | 22.8 | 36.8 | 7.5 | 3 | 43 | Orange |
| 3639 | 15 | 1315 | 191 | 22.8 | 36.8 | 7.5 | 3 | 43 | Blue |
| 3640 | 15 | 1325 | 193 | 22.8 | 36.8 | 7.5 | 3 | 43 | Green |
| 3641 | 15 | 1337 | 196 | 22.8 | 36.8 | 7.5 | 3 | 44 | Orange |
| 3653 | 17 | 1315–1425 | 172–189 | 22.8 | 36.8 | 7.6 | 4 | 44 | Visual |
| 3654 | 17 | 1335 | 177 | 22.8 | 36.8 | 7.6 | 4 | 44 | Orange |
| 3655 | 17 | 1350 | 179 | 22.8 | 36.8 | 7.6 | 4 | 44 | Blue |
| 3656 | 17 | 1400 | 181 | 22.8 | 36.8 | 7.6 | 4 | 44 | Green |
| 3657 | 17 | 1410 | 184 | 22.8 | 36.8 | 7.6 | 4 | 44 | Orange |
| 3670 | 22 | 1116 | 95 | 22.8 | 36.0 | 7.9 | 6 | 46 | Visual |
| 3671 | 22 | 1121 | 95 | 22.8 | 36.0 | 7.9 | 6 | 46 | Blue |
| 3672 | 22 | 1125 | 98 | 22.8 | 36.0 | 7.9 | 6 | 46 | Orange |
| 3675 | 29 | 1112 | 27 | 22.7 | 36.0 | 8.4 | 10 | 50 | Orange |
| 3676 | 29 | 1115 | 29 | 22.7 | 36.0 | 8.4 | 10 | 50 | Orange |
| 3677 | 29 | 1121 | 29 | 22.7 | 36.0 | 8.4 | 10 | 50 | Green |
| 3678 | 29 | 1125 | 31 | 22.7 | 36.0 | 8.4 | 10 | 50 | Blue |
| 3679 | 29 | 1129 | 31 | 22.7 | 36.0 | 8.4 | 10 | 50 | Violet |
| 3680 | 29 | 1109 | 27 | 22.7 | 36.0 | 8.4 | 10 | 50 | Visual |
| 3682 | 30 | 1246 | 41 | 22.7 | 36.0 | 8.4 | 10 | 50 | Visual |
| 3683 | 30 | 1248 | 41 | 22.7 | 36.0 | 8.4 | 10 | 50 | Orange |
| 3684 | 30 | 1252 | 41 | 22.7 | 36.0 | 8.4 | 10 | 50 | Orange |
| 3685 | 30 | 1255 | 44 | 22.7 | 36.0 | 8.4 | 10 | 50 | Green |
| 3686 | 30 | 1259 | 44 | 22.7 | 36.0 | 8.4 | 10 | 50 | Blue |
| 3687 | 30 | 1303 | 44 | 22.7 | 36.0 | 8.4 | 10 | 50 | Violet |
| | 1965 | | | | | | | | |
| 3693 | Jan. 1 | 1201 | 11 | 22.6 | 34.8 | 8.6 | 11 | 51 | Orange |
| 3694 | 1 | 1205 | 13 | 22.6 | 34.8 | 8.6 | 11 | 51 | Orange |
| 3695 | 1 | 1209 | 13 | 22.6 | 34.8 | 8.6 | 11 | 51 | Green |
| 3696 | 1 | 1213 | 13 | 22.6 | 34.8 | 8.6 | 11 | 51 | Blue |
| 3697 | 1 | 1152 | 8 | 22.6 | 34.8 | 8.6 | 11 | 51 | Visual |
| 3698 | 1 | 1232 | 18 | 22.6 | 34.8 | 8.6 | 11 | 51 | Ultraviolet |
| 3699 | 1 | 1236 | 20 | 22.6 | 34.8 | 8.6 | 11 | 51 | Violet |
| 3700 | 1 | 1239 | 20 | 22.6 | 34.8 | 8.6 | 11 | 51 | Blue |
| 3701 | 1 | 1243 | 20 | 22.6 | 34.8 | 8.6 | 11 | 51 | Green |
| 3702 | 1 | 1246 | 23 | 22.6 | 34.8 | 8.6 | 11 | 51 | Green |

| Log No. | TD (UT) | UT | CM, ° | Declination ⊕ (tilt), ° | Terminator, ° | Diameter, ″ | MD | $L_s$, ° | Observation type |
|---|---|---|---|---|---|---|---|---|---|
| 3704 | Jan. 1 | 1310 | 28 | 22.6 | 34.8 | 8.6 | 11 May | 51 | Orange |
| 3705 | 1 | 1314 | 28 | 22.6 | 34.8 | 8.6 | 11 | 51 | Infrared |
| 3706 | 1 | 1317 | 30 | 22.6 | 34.8 | 8.6 | 11 | 51 | Infrared |
| 3707 | 1 | 1322 | 30 | 22.6 | 34.8 | 8.6 | 11 | 51 | Red |
| 3713 | 2 | 1050 | 344 | 22.6 | 34.8 | 8.7 | 11 | 51 | Ultraviolet |
| 3714 | 2 | 1056 | 346 | 22.6 | 34.8 | 8.7 | 11 | 51 | Blue |
| 3715 | 2 | 1103 | 346 | 22.6 | 34.8 | 8.7 | 11 | 51 | Green |
| 3716 | 2 | 1108 | 349 | 22.6 | 34.8 | 8.7 | 11 | 51 | Green |
| 3717 | 2 | 1114 | 349 | 22.6 | 34.8 | 8.7 | 11 | 51 | Orange |
| 3718 | 2 | 1121 | 351 | 22.6 | 34.8 | 8.7 | 11 | 51 | Red |
| 3719 | 2 | 1128 | 354 | 22.6 | 34.8 | 8.7 | 11 | 51 | Infrared |
| 3720 | 2 | 1047 | 344 | 22.6 | 34.8 | 8.7 | 11 | 51 | Visual |
| 3721 | 2 | 1143 | 356 | 22.6 | 34.8 | 8.7 | 11 | 51 | Color |
| 3722 | 2 | 1146 | 359 | 22.6 | 34.8 | 8.7 | 11 | 51 | Color |
| 3725 | 4 | 1219 | 347 | 22.6 | 34.8 | 8.9 | 12 | 52 | Visual |
| 3731 | 9 | 1110 | 284 | 22.6 | 33.7 | 9.2 | 15 | 54 | Visual |
| 3732 | 9 | 1154 | 293 | 22.6 | 33.7 | 9.2 | 15 | 54 | Color |
| 3733 | 9 | 1228 | 303 | 22.6 | 33.7 | 9.2 | 15 | 54 | Blue |
| 3734 | 9 | 1239 | 305 | 22.6 | 33.7 | 9.2 | 15 | 54 | Orange |
| 3735 | 10 | 1240 | 296 | 22.6 | 32.9 | 9.3 | 15 | 55 | Red |
| 3736 | 10 | 1310 | 303 | 22.6 | 32.9 | 9.3 | 15 | 55 | Green |
| 3737 | 10 | 1324 | 306 | 22.6 | 32.9 | 9.3 | 15 | 55 | Blue |
| 3738 | 10 | 1356 | 316 | 22.6 | 32.9 | 9.3 | 15 | 55 | Orange |
| 3738a | 10 | 1230–1424 | 294–321 | 22.6 | 32.9 | 9.3 | 15 | 55 | Visual |
| 3743 | 11 | 1200 | 278 | 22.6 | 32.9 | 9.4 | 15–16 | 55 | Orange |
| 3744 | 11 | 1215 | 281 | 22.6 | 32.9 | 9.4 | 15–16 | 55 | Blue |
| 3745 | 11 | 1231 | 284 | 22.6 | 32.9 | 9.4 | 15–16 | 55 | Green |
| 3746 | 11 | 1248 | 289 | 22.6 | 32.9 | 9.4 | 15–16 | 55 | Violet |
| 3747 | 11 | 1302 | 292 | 22.6 | 32.9 | 9.4 | 15–16 | 55 | Red |
| 3748 | 11 | 1312 | 294 | 22.6 | 32.9 | 9.4 | 15–16 | 55 | Infrared |
| 3749 | 11 | 1328 | 299 | 22.6 | 32.9 | 9.4 | 15–16 | 55 | Color |
| 3750 | 11 | 1335 | 301 | 22.6 | 32.9 | 9.4 | 15–16 | 55 | Visual |
| 3758 | 12 | 1010 | 241 | 22.6 | 32.9 | 9.5 | 16 | 55 | Visual |
| 3759 | 12 | 1201 | 268 | 22.6 | 32.9 | 9.5 | 16 | 55 | Visual |
| 3760 | 12 | 1413 | 299 | 22.6 | 32.9 | 9.5 | 16 | 55 | Orange |
| 3761 | 12 | 1417 | 302 | 22.6 | 32.9 | 9.5 | 16 | 55 | Blue |
| 3764 | 13 | 0926 | 222 | 22.6 | 32.9 | 9.5 | 17 | 56 | Visual |
| 3781 | 21 | 1147 | 182 | 22.6 | 30.7 | 10.2 | 20 | 60 | Blue |
| 3782 | 21 | 1204 | 185 | 22.6 | 30.7 | 10.2 | 20 | 60 | Orange |
| 3783 | 21 | 1219 | 189 | 22.6 | 30.7 | 10.2 | 20 | 60 | Violet |
| 3784 | 21 | 1245 | 197 | 22.6 | 30.7 | 10.2 | 20 | 60 | Red |
| 3785 | 21 | 1304 | 199 | 22.6 | 30.7 | 10.2 | 20 | 60 | Infrared |
| 3792 | 23 | 1156 | 166 | 22.1 | 29.4 | 10.4 | 21 | 61 | Blue |
| 3793 | 23 | 1208 | 169 | 22.1 | 29.4 | 10.4 | 21 | 61 | Red |
| 3794 | 23 | 1238 | 176 | 22.1 | 29.4 | 10.4 | 21 | 61 | Violet |
| 3795 | 23 | 1300 | 181 | 22.1 | 29.4 | 10.4 | 21 | 61 | Orange |
| 3796 | 23 | 1320 | 186 | 22.1 | 29.4 | 10.4 | 21 | 61 | Green |
| 3797 | 23 | 1340 | 191 | 22.1 | 29.4 | 10.4 | 21 | 61 | Green |

| Log No. | TD (UT) | UT | CM, ° | Declination ⊕ (tilt), ° | Terminator, ° | Diameter, " | MD | $L_s$, ° | Observation type |
|---|---|---|---|---|---|---|---|---|---|
| 3798 | Jan. 23 | 1355 | 195 | 22.1 | 29.4 | 10.4 | 21 May | 61 | Visual |
| 3799 | 23 | 1410 | 198 | 22.1 | 29.4 | 10.4 | 21 | 61 | Color |
| 3809 | 26 | 1154 | 136 | 22.1 | 27.9 | 10.8 | 22 | 62 | Visual |
| 3814 | 28 | 1205 | 123 | 22.1 | 27.9 | 11.0 | 23 | 63 | Color |
| 3815 | 28 | 1234 | 128 | 22.1 | 27.9 | 11.0 | 23 | 63 | Orange |
| 3816 | 28 | 1253 | 133 | 22.1 | 27.9 | 11.0 | 23 | 63 | Blue |
| 3817 | 28 | 1321 | 140 | 22.1 | 27.9 | 11.0 | 23 | 63 | Red |
| 3818 | 28 | 1340 | 145 | 22.1 | 27.9 | 11.0 | 23 | 63 | Violet |
| 3819 | 28 | 1402 | 150 | 22.1 | 27.9 | 11.0 | 23 | 63 | Green |
| 3820 | 28 | 1155–1400 | 121–150 | 22.1 | 27.9 | 11.0 | 23 | 63 | Visual |
| 3831 | 29 | 0845 | 65 | 22.1 | 27.9 | 11.0 | 24 | 63 | Visual |
| 3832 | 29 | 0850 | 65 | 22.1 | 27.9 | 11.0 | 24 | 63 | Color |
| 3833 | 29 | 1230 | 119 | 22.1 | 27.9 | 11.0 | 24 | 63 | Visual |
| 3834 | 29 | 1240 | 121 | 22.1 | 27.9 | 11.0 | 24 | 63 | Color |
| 3835 | 29 | 1257 | 126 | 22.1 | 27.9 | 11.0 | 24 | 63 | Violet |
| 3836 | 29 | 1313 | 128 | 22.1 | 27.9 | 11.0 | 24 | 63 | Orange |
| 3837 | 29 | 1328 | 133 | 22.1 | 27.9 | 11.0 | 24 | 63 | Green |
| 3838 | 29 | 1350 | 138 | 22.1 | 27.9 | 11.0 | 24 | 63 | Ultraviolet |
| 3839 | 29 | 1403 | 141 | 22.1 | 27.9 | 11.0 | 24 | 64 | Infrared |
| 3841 | 30 | 1316 | 122 | 22.1 | 26.2 | 11.2 | 24 | 64 | Red |
| 3842 | 30 | 1330 | 124 | 22.1 | 26.2 | 11.2 | 24 | 64 | Green |
| 3843 | 30 | 1355 | 132 | 22.1 | 26.2 | 11.2 | 24 | 64 | Violet |
| 3844 | 30 | 1409 | 134 | 22.1 | 26.2 | 11.2 | 24 | 64 | Blue |
| 3855 | 31 | 0950 | 62 | 22.1 | 26.2 | 11.2 | 25 | 64 | Red |
| 3856 | 31 | 1008 | 67 | 22.1 | 26.2 | 11.2 | 25 | 64 | Blue |
| 3857 | 31 | 1015 | 69 | 22.1 | 26.2 | 11.2 | 25 | 64 | Visual |
| 3871 | Feb. 2 | 0900 | 31 | 22.1 | 25.3 | 11.4 | 26 | 65 | Color |
| 3872 | 2 | 0918 | 36 | 22.1 | 25.3 | 11.4 | 26 | 65 | Orange |
| 3873 | 2 | 0942 | 41 | 22.1 | 25.3 | 11.4 | 26 | 65 | Red |
| 3874 | 2 | 0958 | 46 | 22.1 | 25.3 | 11.4 | 26 | 65 | Blue |
| 3875 | 2 | 1012 | 48 | 22.1 | 25.3 | 11.4 | 26 | 65 | Infrared |
| 3876 | 2 | 1024 | 51 | 22.1 | 25.3 | 11.4 | 26 | 65 | Violet |
| 3877 | 2 | 1041 | 56 | 22.1 | 25.3 | 11.4 | 26 | 65 | Green |
| 3878 | 2 | 1053 | 58 | 22.1 | 25.3 | 11.4 | 26 | 65 | Orange |
| 3879 | 2 | 1114 | 63 | 22.1 | 25.3 | 11.4 | 26 | 65 | Ultraviolet |
| 3880 | 2 | 0850–1128 | 29–68 | 22.1 | 25.3 | 11.4 | 26 | 65 | Visual |
| 3888 | 3 | 0940 | 32 | 22.1 | 24.3 | 11.6 | 26 | 65 | Red |
| 3889 | 3 | 0955 | 37 | 22.1 | 24.3 | 11.6 | 26 | 65 | Blue |
| 3890 | 3 | 1008 | 39 | 22.1 | 24.3 | 11.6 | 26 | 65 | Violet |
| 3891 | 3 | 1019 | 42 | 22.1 | 24.3 | 11.6 | 26 | 65 | Green |
| 3892 | 3 | 1032 | 44 | 22.1 | 24.3 | 11.6 | 26 | 65 | Infrared |
| 3893 | 3 | 1055 | 51 | 22.1 | 24.3 | 11.6 | 26 | 65 | Integrated |
| 3899 | 12 | 0918 | 307 | 21.6 | 19.9 | 12.3 | 30 | 69 | Infrared |
| 3900 | 12 | 0935 | 311 | 21.6 | 19.9 | 12.3 | 30 | 69 | Red |
| 3901 | 12 | 0947 | 314 | 21.6 | 19.9 | 12.3 | 30 | 69 | Green |
| 3902 | 12 | 1015 | 321 | 21.6 | 19.9 | 12.3 | 30 | 69 | Blue |
| 3903 | 12 | 1023 | 321 | 21.6 | 19.9 | 12.3 | 30 | 69 | Violet |
| 3904 | 12 | 1038 | 326 | 21.6 | 19.9 | 12.3 | 30 | 69 | Ultraviolet |

| Log No. | TD (UT) | UT | CM, ° | Declination ⊕ (tilt), ° | Terminator, ° | Diameter, ″ | MD | $L_s$, ° | Observation type |
|---|---|---|---|---|---|---|---|---|---|
| 3907 | Feb. 13 | 1003 | 307 | 21.6 | 18.7 | 12.5 | 31 May | 70 | Orange |
| 3908 | 13 | 1011 | 310 | 21.6 | 18.7 | 12.5 | 31 | 70 | Green |
| 3909 | 13 | 1019 | 312 | 21.6 | 18.7 | 12.5 | 31 | 70 | Blue |
| 3910 | 13 | 1001 | 307 | 21.6 | 18.7 | 12.5 | 31 | 70 | Visual |
| 3911 | 14 | 0829 | 277 | 21.6 | 18.7 | 12.5 | 31 | 70 | Visual |
| KP7 | 14 | 0911 | 286 | 21.6 | 18.7 | 12.5 | 31 | 70 | Visual |
| 3912 | 15 | 0950 | 287 | 21.6 | 17.4 | 12.7 | 1 June | 71 | Orange |
| 3913 | 15 | 1000 | 290 | 21.6 | 17.4 | 12.7 | 1 | 71 | Blue |
| KP8 | 15 | 1000 | 290 | 21.6 | 17.4 | 12.7 | 1 | 71 | Visual |
| 3914 | 15 | 1013 | 292 | 21.6 | 17.4 | 12.7 | 1 | 71 | Visual |
| 3915 | 15 | 0928 | 282 | 21.6 | 17.4 | 12.7 | 1 | 71 | Infrared |
| 3916 | 15 | 0938 | 285 | 21.6 | 17.4 | 12.7 | 1 | 71 | Red |
| KP9 | 15 | 1156–1240 | 319–329 | 21.6 | 17.4 | 12.7 | 1 | 71 | Visual |
| 3917 | 16 | 0946 | 278 | 21.6 | 17.4 | 12.7 | 1 | 71 | Orange |
| 3918 | 16 | 0953 | 278 | 21.6 | 17.4 | 12.7 | 1 | 71 | Green |
| 3919 | 16 | 1002 | 281 | 21.6 | 17.4 | 12.7 | 1 | 71 | Blue |
| 3920 | 16 | 1012 | 283 | 21.6 | 17.4 | 12.7 | 1 | 71 | Violet |
| 3921 | 16 | 1020 | 286 | 21.6 | 17.4 | 12.7 | 1 | 71 | Ultraviolet |
| 3922 | 16 | 1029 | 288 | 21.6 | 17.4 | 12.7 | 1 | 71 | Visual |
| 3931 | 17 | 0830 | 250 | 21.5 | 16.1 | 12.9 | 1 | 71 | Visual |
| 3932 | 17 | 0858 | 257 | 21.5 | 16.1 | 12.9 | 1 | 71 | Green |
| 3933 | 17 | 0913 | 260 | 21.5 | 16.1 | 12.9 | 1 | 71 | Orange |
| 3934 | 17 | 0935 | 267 | 21.5 | 16.1 | 12.9 | 1 | 71 | Blue |
| 3935 | 17 | 0955 | 272 | 21.5 | 16.1 | 12.9 | 1 | 71 | Red |
| 3936 | 17 | 1010 | 274 | 21.5 | 16.1 | 12.9 | 1 | 71 | Violet |
| 3937 | 17 | 1055 | 286 | 21.5 | 16.1 | 12.9 | 1 | 71 | Color |
| 3938 | 17 | 1102 | 286 | 21.5 | 16.1 | 12.9 | 1 | 71 | Color |
| 3939 | 17 | 1223 | 306 | 21.5 | 16.1 | 12.9 | 1 | 71 | Ultraviolet |
| 3940 | 17 | 1233 | 308 | 21.5 | 16.1 | 12.9 | 1 | 71 | Violet |
| 3941 | 17 | 1242 | 311 | 21.5 | 16.1 | 12.9 | 1 | 71 | Blue |
| 3942 | 17 | 1253 | 313 | 21.5 | 16.1 | 12.9 | 1 | 71 | Green |
| 3943 | 17 | 1301 | 316 | 21.5 | 16.1 | 12.9 | 1 | 71 | Orange |
| 3944 | 17 | 1309 | 318 | 21.5 | 26.1 | 12.9 | 1 | 71 | Red |
| 3945 | 17 | 1317 | 321 | 21.5 | 26.1 | 12.9 | 1 | 71 | Infrared |
| 3946 | 17 | 1338 | 325 | 21.5 | 26.1 | 12.9 | 1 | 71 | Visual |
| 3950 | 18 | 0750–0920 | 231–253 | 21.5 | 26.1 | 12.9 | 2 | 72 | Visual |
| 3951 | 18 | 0802 | 234 | 21.5 | 26.1 | 12.9 | 2 | 72 | Red |
| 3952 | 18 | 0817 | 239 | 21.5 | 26.1 | 12.9 | 2 | 72 | Green |
| 3953 | 18 | 0833 | 241 | 21.5 | 26.1 | 12.9 | 2 | 72 | Blue |
| 3954 | 18 | 0847 | 246 | 21.5 | 26.1 | 12.9 | 2 | 72 | Violet |
| 3955 | 18 | 0859 | 248 | 21.5 | 26.1 | 12.1 | 2 | 72 | Orange |
| 3959 | 19 | 0748–1104 | 223–269 | 21.5 | 14.7 | 13.1 | 2 | 72 | Visual |
| 3960 | 19 | 0802 | 225 | 21.5 | 14.7 | 13.1 | 2 | 72 | Green |
| 3961 | 19 | 0831 | 232 | 21.5 | 14.7 | 13.1 | 2 | 72 | Blue |
| 3962 | 19 | 0855 | 240 | 21.5 | 14.7 | 13.1 | 2 | 72 | Violet |
| 3963 | 19 | 0925 | 247 | 21.5 | 14.7 | 13.1 | 2 | 72 | Orange |
| 3964 | 19 | 0943 | 249 | 21.5 | 14.7 | 13.1 | 2 | 72 | Red |
| 3965 | 19 | 1011 | 257 | 21.5 | 14.7 | 13.1 | 2 | 72 | Ultraviolet |

| Log No. | TD (UT) | UT | CM, ° | Declination ⊕ (tilt), ° | Terminator, ° | Diameter, " | MD | $L_s$, ° | Observation type |
|---|---|---|---|---|---|---|---|---|---|
| 3966 | Feb. 19 | 1038 | 264 | 21.5 | 14.7 | 13.1 | 2 June | 72 | Color |
| 3968 | 19 | 1159 | 284 | 21.5 | 14.7 | 13.1 | 2 | 72 | Color |
| 3969 | 19 | 1217 | 288 | 21.5 | 14.7 | 13.1 | 2 | 72 | Infrared |
| 3970 | 19 | 1238 | 293 | 21.5 | 14.7 | 13.1 | 2 | 72 | Orange |
| 3974 | 20 | 0640 | 197 | 21.5 | 14.7 | 13.1 | 3 | 73 | Blue |
| 3975 | 20 | 0655 | 202 | 21.5 | 14.7 | 13.1 | 3 | 73 | Green |
| 3976 | 20 | 0708 | 204 | 21.5 | 14.7 | 13.1 | 3 | 73 | Red |
| 3977 | 20 | 0725 | 209 | 21.5 | 14.7 | 13.1 | 3 | 73 | Violet |
| 3978 | 20 | 0636–0911 | 197–233 | 21.5 | 14.7 | 13.1 | 3 | 73 | Visual |
| 3979 | 20 | 0755 | 216 | 21.5 | 14.7 | 13.1 | 3 | 73 | Color |
| 3980 | 20 | 0809 | 219 | 21.5 | 14.7 | 13.1 | 3 | 73 | Orange |
| 3986 | 20 | 1134 | 267 | 21.5 | 14.7 | 13.1 | 3 | 73 | Visual |
| 3987 | 20 | 1139 | 270 | 21.5 | 14.7 | 13.1 | 3 | 73 | Color |
| 3989 | 20 | 1146 | 272 | 21.5 | 14.7 | 13.1 | 3 | 73 | Orange |
| 3990 | 20 | 1150 | 272 | 21.5 | 14.7 | 13.1 | 3 | 73 | Red |
| 3991 | 20 | 1158 | 275 | 21.5 | 14.7 | 13.1 | 3 | 73 | Blue |
| 3992 | 20 | 1204 | 275 | 21.5 | 14.7 | 13.1 | 3 | 73 | Violet |
| 3993 | 20 | 1216 | 280 | 21.5 | 14.7 | 13.1 | 3 | 73 | Orange |
| 3994 | 20 | 1228 | 282 | 21.5 | 14.7 | 13.1 | 3 | 73 | Violet |
| 3995 | 20 | 1242 | 284 | 21.5 | 14.7 | 13.1 | 3 | 73 | Green |
| 3997 | 21 | 1038–1200 | 246–266 | 21.5 | 13.3 | 13.2 | 3 | 73 | Visual |
| 3998 | 21 | 1043 | 246 | 21.5 | 13.3 | 13.2 | 3 | 73 | Orange |
| 3999 | 21 | 1054 | 249 | 21.5 | 13.3 | 13.2 | 3 | 73 | Green |
| 4000 | 21 | 1108 | 254 | 21.5 | 13.3 | 13.2 | 3 | 73 | Blue |
| 4001 | 21 | 1119 | 256 | 21.5 | 13.3 | 13.2 | 3 | 73 | Red |
| 4002 | 21 | 1130 | 259 | 21.5 | 13.3 | 13.2 | 3 | 73 | Violet |
| 4003 | 21 | 1145 | 263 | 21.5 | 13.3 | 13.2 | 3 | 73 | Color |
| 4004 | 22 | 0735 | 194 | 21.5 | 13.0 | 13.2 | 5 | 74 | Blue |
| 4005 | 25 | 0725–0821 | 165–177 | 21.4 | 10.4 | 13.5 | 5 | 75 | Visual |
| 4006 | 25 | 0735 | 167 | 21.4 | 10.4 | 13.5 | 5 | 75 | Blue |
| 4007 | 25 | 0748 | 170 | 21.4 | 10.4 | 13.5 | 5 | 75 | Red |
| 4008 | 25 | 0809 | 175 | 21.4 | 10.4 | 13.5 | 5 | 75 | Green |
| 4011 | 26 | 0647 | 147 | 21.4 | 10.4 | 13.5 | 5–6 | 75 | Visual |
| 4012 | 26 | 0651 | 147 | 21.4 | 10.4 | 13.5 | 5–6 | 75 | Blue |
| 4013 | 26 | 0701 | 149 | 21.4 | 10.4 | 13.5 | 5–6 | 75 | Green |
| 4014 | 26 | 0711 | 151 | 21.4 | 10.4 | 13.5 | 5–6 | 75 | Red |
| 4015 | 26 | 1238 | 232 | 21.4 | 10.4 | 13.5 | 5–6 | 75 | Violet |
| 4016 | 26 | 1248 | 234 | 21.4 | 10.4 | 13.5 | 5–6 | 75 | Blue |
| 4017 | 26 | 1258 | 237 | 21.4 | 10.4 | 13.5 | 5–6 | 75 | Green |
| 4018 | 26 | 1310 | 239 | 21.4 | 10.4 | 13.5 | 5–6 | 75 | Red |
| 4019 | 26 | 1321 | 242 | 21.4 | 10.4 | 13.5 | 5–6 | 75 | Orange |
| 4020 | 26 | 1329 | 244 | 21.4 | 10.4 | 13.5 | 5–6 | 75 | Ultraviolet |
| 4021 | 26 | 1341 | 246 | 21.4 | 10.4 | 13.5 | 5–6 | 75 | Infrared |
| 4022 | 26 | 1351 | 249 | 21.4 | 10.4 | 13.5 | 5–6 | 75 | Visual |
| 4024 | 27 | 0620 | 130 | 21.4 | 8.9 | 13.6 | 6 | 76 | Orange |
| 4025 | 27 | 0629 | 133 | 21.4 | 8.9 | 13.6 | 6 | 76 | Green |
| 4026 | 27 | 0638 | 135 | 21.4 | 8.9 | 13.6 | 6 | 76 | Blue |
| 4027 | 27 | 0647 | 138 | 21.4 | 8.9 | 13.6 | 6 | 76 | Visual |

| Log No. | TD (UT) | UT | CM, ° | Declination ⊕ (tilt), ° | Terminator, ° | Diameter, " | MD | $L_s$, ° | Observation type |
|---|---|---|---|---|---|---|---|---|---|
| 4028 | Mar. 1 | 0737 | 133 | 21.4 | 7.4 | 13.7 | 7 June | 77 | Green |
| 4029 | 1 | 0752 | 135 | 21.4 | 7.4 | 13.7 | 7 | 77 | Orange |
| 4030 | 1 | 0803 | 137 | 21.4 | 7.4 | 13.7 | 7 | 77 | Red |
| 4031 | 1 | 1241 | 206 | 21.4 | 7.4 | 13.7 | 7 | 77 | Visual |
| 4032 | 2 | 0650 | 112 | 21.4 | 7.4 | 13.7 | 8 | 77 | Blue |
| 4033 | 2 | 0658 | 114 | 21.4 | 7.4 | 13.7 | 8 | 77 | Green |
| 4034 | 2 | 0709 | 117 | 21.4 | 7.4 | 13.7 | 8 | 77 | Orange |
| 4035 | 2 | 0718 | 119 | 21.4 | 7.4 | 13.7 | 8 | 77 | Red |
| 4036 | 4 | 0810 | 114 | 21.4 | 5.9 | 13.8 | 8 | 78 | Blue |
| 4037 | 4 | 0825 | 119 | 21.4 | 5.9 | 13.8 | 8 | 78 | Violet |
| 4038 | 4 | 0800 | 111 | 21.4 | 5.9 | 13.8 | 8 | 78 | Visual |
| 4039 | 6 | 0705 | 82 | 21.3 | 4.5 | 13.9 | 9 | 79 | Red |
| 4040 | 6 | 0723 | 84 | 21.3 | 4.5 | 13.9 | 9 | 79 | Blue |
| 4041 | 6 | 0740 | 89 | 21.3 | 4.5 | 13.9 | 9 | 79 | Green |
| 4042 | 6 | 1047 | 135 | 21.3 | 4.5 | 13.9 | 9 | 79 | Violet |
| 4043 | 6 | 1102 | 138 | 21.3 | 4.5 | 13.9 | 9 | 79 | Green |
| 4044 | 6 | 1115 | 143 | 21.3 | 4.5 | 13.9 | 9 | 79 | Orange |
| 4045 | 8 | 0624 | 52 | 21.3 | 3.2 | 13.9 | 10 | 80 | Orange |
| 4046 | 8 | 0640 | 57 | 21.3 | 3.2 | 13.9 | 10 | 80 | Blue |
| 4047 | 8 | 0657 | 62 | 21.3 | 3.2 | 13.9 | 10 | 80 | Red |
| 4048 | 8 | 0710 | 64 | 21.3 | 3.2 | 13.9 | 10 | 80 | Green |
| 4049 | 8 | 0721 | 67 | 21.3 | 3.2 | 13.9 | 10 | 80 | Violet |
| 4050 | 8 | 0745 | 74 | 21.3 | 3.2 | 13.9 | 10 | 80 | Visual |
| 4051 | 8 | 1120 | 125 | 21.3 | 3.2 | 13.9 | 10 | 80 | Blue |
| 4052 | 8 | 1124 | 125 | 21.3 | 3.2 | 13.9 | 10 | 80 | Blue |
| 4053 | 8 | 1129 | 128 | 21.3 | 3.2 | 13.9 | 10 | 80 | Violet |
| 4054 | 8 | 1133 | 128 | 21.3 | 3.2 | 13.9 | 10 | 80 | Visual |
| AG10 | 9 | 0735 | 63 | 21.3 | 2.4 | 14.0 | 11 | 80 | Blue |
| AG11 | 9 | 0750 | 65 | 21.3 | 2.4 | 14.0 | 11 | 80 | Violet |
| AG12 | 9 | 0801 | 68 | 21.3 | 2.4 | 14.0 | 11 | 80 | Color |
| 4055 | 9 | 1012 | 100 | 21.3 | 2.4 | 14.0 | 11 | 80 | Visual |
| 4056 | 9 | 1018 | 102 | 21.3 | 2.4 | 14.0 | 11 | 80 | Blue |
| 4057 | 9 | 1021 | 102 | 21.3 | 2.4 | 14.0 | 11 | 80 | Blue |
| 4058 | 9 | 1025 | 104 | 21.3 | 2.4 | 14.0 | 11 | 80 | Violet |
| AG13 | 9 | 0630–0820 | 46–73 | 21.3 | 2.4 | 14.0 | 11 | 80 | Visual |
| 4059 | 9 | 1043 | 107 | 21.3 | 2.4 | 14.0 | 11 | 80 | Green |
| 4060 | 9 | 1052 | 109 | 21.3 | 2.4 | 14.0 | 11 | 80 | Red |
| 4061 | 9 | 1101 | 112 | 21.3 | 2.4 | 14.0 | 11 | 80 | Orange |
| AG14 | 10 | 0453–0600 | 13–30 | 21.3 | 2.4 | 14.0 | 11 | 81 | Visual |
| 4062 | 10 | 0612 | 32 | 21.3 | 2.4 | 14.0 | 11 | 81 | Blue |
| 4063 | 10 | 0626 | 37 | 21.3 | 2.4 | 14.0 | 11 | 81 | Ultraviolet |
| 4064 | 10 | 0633 | 37 | 21.3 | 2.4 | 14.0 | 11 | 81 | Green |
| 4065 | 10 | 0641 | 40 | 21.3 | 2.4 | 14.0 | 11 | 81 | Orange |
| AG15 | 10 | 0644 | 40 | 21.3 | 2.4 | 14.0 | 11 | 81 | Intregrated |
| 4066 | 10 | 0650 | 42 | 21.3 | 2.4 | 14.0 | 11 | 81 | Red |
| AG16a | 10 | 0655 | 45 | 21.3 | 2.4 | 14.0 | 11 | 81 | Orange |
| AG16b | 10 | 0702 | 45 | 21.3 | 2.4 | 14.0 | 11 | 81 | Red |
| AG17 | 10 | 0720 | 49 | 21.3 | 2.4 | 14.0 | 11 | 81 | Green |

| Log No. | TD (UT) | UT | CM, ° | Declination ⊕ (tilt), ° | Terminator, ° | Diameter, ″ | MD | $L_s$, ° | Observation type |
|---|---|---|---|---|---|---|---|---|---|
| AG18 | Mar. 10 | 0726 | 52 | 21.3 | 2.4 | 14.0 | 11 June | 81 | Blue |
| AG19 | 10 | 0746 | 57 | 21.3 | 2.4 | 14.0 | 11 | 81 | Color |
| 4067 | 10 | 1103 | 103 | 21.3 | 2.4 | 14.0 | 11 | 81 | Violet |
| 4068 | 10 | 1113 | 106 | 21.3 | 2.4 | 14.0 | 11 | 81 | Blue |
| 4069 | 10 | 1120 | 108 | 21.3 | 2.4 | 14.0 | 11 | 81 | Green |
| 4070 | 10 | 1130 | 110 | 21.3 | 2.4 | 14.0 | 11 | 81 | Orange |
| 4071 | 10 | 1139 | 113 | 21.3 | 2.4 | 14.0 | 11 | 81 | Red |
| 4072 | 10 | 1056–1159 | 103–118 | 21.3 | 2.4 | 14.0 | 11 | 81 | Visual |
| AG20 | 15 | 0830–1100 | 23–60 | 21.3 | 5.1 | 14.0 | 13 | 83 | Visual |
| AG21 | 15 | 0918 | 35 | 21.3 | 5.1 | 14.0 | 13 | 83 | Color |
| AG22 | 15 | 0936 | 40 | 21.3 | 5.1 | 14.0 | 13 | 83 | Blue |
| AG23 | 15 | 0950 | 43 | 21.3 | 5.1 | 14.0 | 13 | 83 | Red |
| AG24 | 15 | 1020 | 50 | 21.3 | 5.1 | 14.0 | 13 | 83 | Violet |
| AG25 | 15 | 1040 | 55 | 21.3 | 5.1 | 14.0 | 13 | 83 | Green |
| 4073 | 16 | 0516 | 328 | 21.3 | 5.1 | 14.0 | 14 | 83 | Blue |
| 4074 | 16 | 0524 | 328 | 21.3 | 5.1 | 14.0 | 14 | 83 | Green |
| 4075 | 16 | 0535 | 333 | 21.3 | 5.1 | 14.0 | 14 | 83 | Orange |
| 4076 | 16 | 0543 | 333 | 21.3 | 5.1 | 14.0 | 14 | 83 | Red |
| 4077 | 16 | 0553 | 335 | 21.3 | 5.1 | 14.0 | 14 | 83 | Violet |
| 4078 | 16 | 1011 | 39 | 21.3 | 5.1 | 14.0 | 14 | 83 | Visual |
| 4079 | 16 | 1015 | 41 | 21.3 | 5.1 | 14.0 | 14 | 83 | Blue |
| 4080 | 16 | 1025 | 44 | 21.3 | 5.1 | 14.0 | 14 | 83 | Orange |
| 4081 | 17 | 0553 | 327 | 21.2 | 6.6 | 14.0 | 14 | 84 | Blue |
| 4082 | 17 | 0602 | 329 | 21.2 | 6.6 | 14.0 | 14 | 84 | Green |
| 4083 | 17 | 0609 | 332 | 21.2 | 6.6 | 14.0 | 14 | 84 | Orange |
| 4084 | 17 | 0620 | 334 | 21.2 | 6.6 | 14.0 | 14 | 84 | Violet |
| 4085 | 17 | 1058 | 42 | 21.2 | 6.6 | 14.0 | 14 | 84 | Visual |
| AG26 | 18 | 0430–0532 | 298–313 | 21.2 | 6.6 | 14.0 | 15 | 84 | Visual |
| AG27 | 18 | 0540 | 316 | 21.2 | 6.6 | 14.0 | 15 | 84 | Blue |
| AG28 | 18 | 0552 | 318 | 21.2 | 6.6 | 14.0 | 15 | 84 | Color |
| AG29 | 19 | 0515–0645 | 302–324 | 21.2 | 8.1 | 13.9 | 15 | 85 | Visual |
| AG30 | 19 | 0536 | 307 | 21.2 | 8.1 | 13.9 | 15 | 85 | Orange |
| AG31 | 19 | 0547 | 309 | 21.2 | 8.1 | 13.9 | 15 | 85 | Violet |
| AG32 | 19 | 0554 | 309 | 21.2 | 8.1 | 13.9 | 15 | 85 | Red |
| AG33 | 19 | 0600 | 312 | 21.2 | 8.1 | 13.9 | 15 | 85 | Green |
| AG34 | 19 | 0608 | 314 | 21.2 | 8.1 | 13.9 | 15 | 85 | Color |
| AG35 | 19 | 0627 | 319 | 21.2 | 8.1 | 13.9 | 15 | 85 | Red |
| AG36 | 19 | 0715–1000 | 331–10 | 21.2 | 8.1 | 13.9 | 15 | 85 | Visual |
| AG37 | 19 | 0920 | 0 | 21.2 | 8.1 | 13.9 | 15 | 85 | Violet |
| AG38 | 19 | 0930 | 3 | 21.2 | 8.1 | 13.9 | 15 | 85 | Green |
| AG39 | 19 | 0938 | 5 | 21.2 | 8.1 | 13.9 | 15 | 85 | Blue |
| AG40 | 19 | 0943 | 5 | 21.2 | 8.1 | 13.9 | 15 | 85 | Orange |
| 4086 | 19 | 0951 | 8 | 21.2 | 8.1 | 13.9 | 15 | 85 | Red |
| 4087 | 19 | 1000 | 10 | 21.2 | 8.1 | 13.9 | 15 | 85 | Orange |
| 4088 | 19 | 1010 | 13 | 21.2 | 8.1 | 13.9 | 15 | 85 | Green |
| 4089 | 19 | 1019 | 15 | 21.2 | 8.1 | 13.9 | 15 | 85 | Blue |
| 4090 | 19 | 1026 | 17 | 21.2 | 8.1 | 13.9 | 15 | 85 | Violet |
| 4091 | 19 | 1051 | 22 | 21.2 | 8.1 | 13.9 | 15 | 85 | Visual |

| Log No. | TD (UT) | UT | CM, ° | Declination ⊕ (tilt), ° | Terminator, ° | Diameter, ″ | MD | $L_s$, ° | Observation type |
|---|---|---|---|---|---|---|---|---|---|
| AG41 | Mar. 20 | 0435 | 283 | 21.2 | 8.1 | 13.9 | 16 June | 85 | Color |
| AG42 | 20 | 0452 | 286 | 21.2 | 8.1 | 13.9 | 16 | 85 | Integrated |
| AG43 | 20 | 0500 | 288 | 21.2 | 8.1 | 13.9 | 16 | 85 | Violet |
| AG44 | 20 | 0512 | 291 | 21.2 | 8.1 | 13.9 | 16 | 85 | Red |
| AG45 | 20 | 0340–0525 | 269–296 | 21.2 | 8.1 | 13.9 | 16 | 85 | Visual |
| 4092 | 20 | 0838 | 342 | 21.2 | 8.1 | 13.9 | 16 | 85 | Infrared |
| 4093 | 20 | 0846 | 344 | 21.2 | 8.1 | 13.9 | 16 | 85 | Red |
| 4094 | 20 | 0853 | 344 | 21.2 | 8.1 | 13.9 | 16 | 85 | Orange |
| 4095 | 20 | 0903 | 347 | 21.2 | 8.1 | 13.9 | 16 | 85 | Green |
| 4096 | 20 | 0910 | 349 | 21.2 | 8.1 | 13.9 | 16 | 85 | Blue |
| 4097 | 20 | 0917 | 352 | 21.2 | 8.1 | 13.9 | 16 | 85 | Violet |
| 4098 | 20 | 0927 | 354 | 21.2 | 8.1 | 13.9 | 16 | 85 | Ultraviolet |
| 4099 | 20 | 0938 | 357 | 21.2 | 8.1 | 13.9 | 16 | 85 | Integrated |
| 4100 | 20 | 0947 | 359 | 21.2 | 8.1 | 13.9 | 16 | 85 | Color |
| 4101 | 20 | 0831–0958 | 340–341 | 21.2 | 8.1 | 13.9 | 16 | 85 | Visual |
| 4102 | 21 | 0457 | 280 | 21.2 | 9.7 | 13.8 | 16 | 85 | Color |
| 4103 | 21 | 0504 | 280 | 21.2 | 9.7 | 13.8 | 16 | 85 | Orange |
| 4104 | 21 | 0510 | 282 | 21.2 | 9.7 | 13.8 | 16 | 85 | Blue |
| 4105 | 21 | 0513 | 282 | 21.2 | 9.7 | 13.8 | 16 | 85 | Blue |
| 4106 | 21 | 0517 | 284 | 21.2 | 9.7 | 13.8 | 16 | 85 | Violet |
| 4107 | 21 | 0531 | 287 | 21.2 | 9.7 | 13.8 | 16 | 85 | Color |
| 4108 | 21 | 0449–0546 | 277–291 | 21.2 | 9.7 | 13.8 | 16 | 85 | Visual |
| 4109 | 21 | 0549 | 292 | 21.2 | 9.7 | 13.8 | 16 | 85 | Infrared |
| 4110 | 21 | 0558 | 294 | 21.2 | 9.7 | 13.8 | 16 | 85 | Red |
| 4111 | 21 | 0605 | 297 | 21.2 | 9.7 | 13.8 | 16 | 85 | Orange |
| 4112 | 21 | 0611 | 297 | 21.2 | 9.7 | 13.8 | 16 | 85 | Green |
| 4113 | 21 | 0618 | 299 | 21.2 | 9.7 | 13.8 | 16 | 85 | Blue |
| 4114 | 21 | 0625 | 301 | 21.2 | 9.7 | 13.8 | 16 | 85 | Violet |
| 4115 | 21 | 0634 | 301 | 21.2 | 9.7 | 13.8 | 16 | 85 | Ultraviolet |
| AG45a | 21 | 0645 | 306 | 21.2 | 9.7 | 13.8 | 16 | 85 | Visual |
| AG46 | 23 | 0535–0830 | 272–313 | 21.2 | 11.2 | 13.7 | 17 | 86 | Visual |
| AG47 | 23 | 0555 | 277 | 21.2 | 11.2 | 13.7 | 17 | 86 | Red |
| AG48 | 23 | 0607 | 279 | 21.2 | 11.2 | 13.7 | 17 | 86 | Color |
| AG49 | 23 | 0645 | 289 | 21.2 | 11.2 | 13.7 | 17 | 86 | Color |
| AG50 | 23 | 0706 | 294 | 21.2 | 11.2 | 13.7 | 17 | 86 | Integrated |
| AG51 | 23 | 0711 | 294 | 21.2 | 11.2 | 13.7 | 17 | 86 | Orange |
| AG52 | 23 | 0718 | 296 | 21.2 | 11.2 | 13.7 | 17 | 86 | Blue |
| AG53 | 23 | 0725 | 299 | 21.2 | 11.2 | 13.7 | 17 | 86 | Green |
| AG54 | 23 | 0750 | 304 | 21.2 | 11.2 | 13.7 | 17 | 86 | Red |
| AG55 | 23 | 0756 | 306 | 21.2 | 11.2 | 13.7 | 17 | 86 | Green |
| AG56 | 23 | 0805 | 308 | 21.2 | 11.2 | 13.7 | 17 | 86 | Violet |
| AG57 | 23 | 0818 | 311 | 21.2 | 11.2 | 13.7 | 17 | 86 | Green |
| 4116 | 26 | 0517 | 241 | 21.2 | 12.7 | 13.6 | 19 | 88 | Blue |
| 4117 | 26 | 0526 | 243 | 21.2 | 12.7 | 13.6 | 19 | 88 | Green |
| 4118 | 26 | 0535 | 246 | 21.2 | 12.7 | 13.6 | 19 | 88 | Orange |
| 4119 | 26 | 0542 | 246 | 21.2 | 12.7 | 13.6 | 19 | 88 | Red |
| 4120 | 26 | 0938 | 304 | 21.2 | 12.7 | 13.6 | 19 | 88 | Visual |
| AG58 | 27 | 0436 | 222 | 21.2 | 14.2 | 13.5 | 19 | 88 | Color |

| Log No. | TD (UT) | UT | CM, ° | Declination ⊕ (tilt), ° | Terminator, ° | Diameter, " | MD | $L_s$, ° | Observation type |
|---|---|---|---|---|---|---|---|---|---|
| AG59 | Mar. 27 | 0530 | 234 | 21.2 | 14.2 | 13.5 | 19 June | 88 | Blue |
| AG60 | 27 | 0540 | 237 | 21.2 | 14.2 | 13.5 | 19 | 88 | Violet |
| AG61 | 27 | 0351–0600 | 210–242 | 21.2 | 14.2 | 13.5 | 19 | 88 | Visual |
| AG62 | 28 | 0556–0730 | 233–255 | 21.2 | 14.2 | 13.5 | 19 | 89 | Visual |
| AG63 | 28 | 0615 | 238 | 21.2 | 14.2 | 13.5 | 19 | 89 | Color |
| AG64 | 28 | 0625 | 240 | 21.2 | 14.2 | 13.5 | 19 | 89 | Color |
| AG65 | 28 | 0638 | 243 | 21.2 | 14.2 | 13.5 | 19 | 89 | Blue |
| AG66 | 28 | 0645 | 245 | 21.2 | 14.2 | 13.5 | 19 | 89 | Violet |
| AG67 | 28 | 0702 | 248 | 21.2 | 14.2 | 13.5 | 19 | 89 | Red |
| AG68 | 28 | 0710 | 250 | 21.2 | 14.2 | 13.5 | 19 | 89 | Red |
| AG69 | 28 | 0735 | 257 | 21.2 | 14.2 | 13.5 | 19 | 89 | Color |
| AG70 | 29 | 0630–0756 | 231–253 | 21.2 | 15.6 | 13.4 | 20 | 89 | Visual |
| AG71 | 29 | 0705 | 241 | 21.2 | 15.6 | 13.4 | 20 | 89 | Green |
| AG72 | 29 | 0718 | 244 | 21.2 | 15.6 | 13.4 | 20 | 89 | Blue |
| AG73 | 29 | 0725 | 246 | 21.2 | 15.6 | 13.4 | 20 | 89 | Violet |
| AG74 | 29 | 0744 | 249 | 21.2 | 15.6 | 13.4 | 20 | 89 | Orange |
| 4121 | 29 | 0800 | 253 | 21.2 | 15.6 | 13.4 | 20 | 89 | Ultraviolet |
| AG75 | 30 | 0408–0835 | 188–254 | 21.2 | 15.6 | 13.4 | 20 | 89 | Visual |
| AG76 | 30 | 0407 | 188 | 21.2 | 15.6 | 13.4 | 20 | 89 | Orange |
| AG77 | 30 | 0422 | 191 | 21.2 | 15.6 | 13.4 | 20 | 89 | Green |
| 4122 | 30 | 0425 | 193 | 21.2 | 15.6 | 13.4 | 20 | 89 | Infrared |
| AG78 | 30 | 0433 | 193 | 21.2 | 15.6 | 13.4 | 20 | 89 | Blue |
| AG79 | 30 | 0437 | 196 | 21.2 | 15.6 | 13.4 | 20 | 89 | Violet |
| 4123 | 30 | 0438 | 196 | 21.2 | 15.6 | 13.4 | 20 | 89 | Red |
| 4124 | 30 | 0448 | 198 | 21.2 | 15.6 | 13.4 | 20 | 89 | Orange |
| 4125 | 30 | 0459 | 201 | 21.2 | 15.6 | 13.4 | 20 | 89 | Green |
| 4126 | 30 | 0506 | 203 | 21.2 | 15.6 | 13.4 | 20 | 89 | Blue |
| 4127 | 30 | 0514 | 203 | 21.2 | 15.6 | 13.4 | 20 | 89 | Violet |
| 4128 | 30 | 0524 | 206 | 21.2 | 15.6 | 13.4 | 20 | 89 | Ultraviolet |
| AG80 | 30 | 0545 | 213 | 21.2 | 15.6 | 13.4 | 20 | 89 | Red |
| AG81 | 30 | 0552 | 213 | 21.2 | 15.6 | 13.4 | 20 | 89 | Color |
| AG82 | 30 | 0610 | 218 | 21.2 | 15.6 | 13.4 | 20 | 89 | Green |
| AG83 | 30 | 0735 | 240 | 21.2 | 15.6 | 13.4 | 20 | 89 | Green |
| AG84 | 30 | 0745 | 242 | 21.2 | 15.6 | 13.4 | 20 | 89 | Blue |
| AG85 | 30 | 0758 | 245 | 21.2 | 15.6 | 13.4 | 20 | 89 | Violet |
| AG86 | 30 | 0812 | 247 | 21.2 | 15.6 | 13.4 | 20 | 89 | Red |
| AG87 | 30 | 0823 | 249 | 21.2 | 15.6 | 13.4 | 20 | 89 | Color |
| AG88 | 31 | 0353 | 175 | 21.2 | 17.0 | 13.3 | 21 | 90 | Color |
| AG89 | 31 | 0410 | 180 | 21.2 | 17.0 | 13.3 | 21 | 90 | Red |
| AG90 | 31 | 0423 | 182 | 21.2 | 17.0 | 13.3 | 21 | 90 | Blue |
| AG91 | 31 | 0429 | 184 | 21.2 | 17.0 | 13.3 | 21 | 90 | Violet |
| AG92 | 31 | 0445 | 189 | 21.2 | 17.0 | 13.3 | 21 | 90 | Green |
| AG93 | 31 | 0515 | 197 | 21.2 | 17.0 | 13.3 | 21 | 90 | Color |
| AG94 | 31 | 0605 | 209 | 21.2 | 17.0 | 13.3 | 21 | 90 | Color |
| AG95 | 31 | 0644 | 216 | 21.2 | 17.0 | 13.3 | 21 | 90 | Color |
| AG96 | 31 | 0715 | 226 | 21.2 | 17.0 | 13.3 | 21 | 90 | Green |
| AG97 | 31 | 0723 | 226 | 21.2 | 17.0 | 13.3 | 21 | 90 | Orange |
| AG98 | 31 | 0727 | 228 | 21.2 | 17.0 | 13.3 | 21 | 90 | Red |

| Log No. | TD (UT) | UT | CM, ° | Declination ⊕ (tilt), ° | Terminator, ° | Diameter, ″ | MD | $L_s$, ° | Observation type |
|---|---|---|---|---|---|---|---|---|---|
| AG99 | Mar. 31 | 0734 | 228 | 21.2 | 17.0 | 13.3 | 21 June | 90 | Red |
| AG100 | 31 | 0739 | 231 | 21.2 | 17.0 | 13.3 | 21 | 90 | Blue |
| AG101 | 31 | 0753 | 233 | 21.2 | 17.0 | 13.3 | 21 | 90 | Violet |
| AG102 | 31 | 0759 | 236 | 21.2 | 17.0 | 13.3 | 21 | 90 | Red |
| AG103 | 31 | 0350–0827 | 175–243 | 21.2 | 17.0 | 13.3 | 21 | 90 | Visual |
| AG104 | Apr. 1 | 0558 | 198 | 21.2 | 17.0 | 13.3 | 21 | 90 | Blue |
| AG105 | 1 | 0605 | 200 | 21.2 | 17.0 | 13.3 | 21 | 90 | Violet |
| AG106 | 1 | 0613 | 200 | 21.2 | 17.0 | 13.3 | 21 | 90 | Orange |
| AG107 | 1 | 0638–0751 | 207–224 | 21.2 | 17.0 | 13.3 | 21 | 90 | Visual |
| AG108 | 16 | 0414–0611 | 36–66 | 21.5 | 26.5 | 11.9 | 28 | 97 | Visual |
| AG109 | 16 | 0436 | 44 | 21.5 | 26.5 | 11.9 | 28 | 97 | Color |
| AG110 | 16 | 0445 | 46 | 21.5 | 26.5 | 11.9 | 28 | 97 | Green |
| AG111 | 16 | 0527 | 56 | 21.5 | 26.5 | 11.9 | 28 | 97 | Blue |
| AG112 | 16 | 0533 | 56 | 21.5 | 26.5 | 11.9 | 28 | 97 | Violet |
| AG113 | 16 | 0541 | 58 | 21.5 | 26.5 | 11.9 | 28 | 97 | Red |
| AG114 | 16 | 0556 | 63 | 21.5 | 26.5 | 11.9 | 28 | 97 | Color |
| AG115 | 16 | 0614 | 66 | 21.5 | 26.5 | 11.9 | 28 | 97 | Green |
| AG116 | 17 | 0430–0535 | 32–49 | 21.5 | 26.5 | 11.9 | 29 | 97 | Visual |
| AG117 | 17 | 0501 | 40 | 21.5 | 26.5 | 11.9 | 29 | 97 | Green |
| AG118 | 17 | 0506 | 42 | 21.5 | 26.5 | 11.9 | 29 | 97 | Blue |
| AG119 | 17 | 0511 | 42 | 21.5 | 26.5 | 11.9 | 29 | 97 | Violet |
| AG120 | 17 | 0529 | 47 | 21.5 | 26.5 | 11.9 | 29 | 97 | Red |
| AG121 | 19 | 0514 | 24 | 21.7 | 27.5 | 11.7 | 30 | 98 | Red |
| AG122 | 19 | 0520 | 26 | 21.7 | 27.5 | 11.7 | 30 | 98 | Blue |
| AG123 | 19 | 0524 | 26 | 21.7 | 27.5 | 11.7 | 30 | 98 | Violet |
| AG124 | 19 | 0330–0530 | 359–29 | 21.7 | 27.5 | 11.7 | 30 | 98 | Visual |
| AG125 | 20 | 0538 | 22 | 21.7 | 28.4 | 11.5 | 30 | 99 | Blue |
| AG126 | 20 | 0543 | 23 | 21.7 | 28.4 | 11.5 | 30 | 99 | Violet |
| AG127 | 20 | 0550 | 24 | 21.7 | 28.4 | 11.5 | 30 | 99 | Integrated |
| AG128 | 20 | 0605 | 29 | 21.7 | 28.4 | 11.5 | 30 | 99 | Red |
| AG129 | 20 | 0610 | 29 | 21.7 | 28.4 | 11.5 | 30 | 99 | Green |
| AG130 | 20 | 0624 | 32 | 21.7 | 28.4 | 11.5 | 30 | 99 | Red |
| AG131 | 20 | 0645 | 39 | 21.7 | 28.4 | 11.5 | 30 | 99 | Color |
| AG132 | 20 | 0716 | 46 | 21.7 | 28.4 | 11.5 | 30 | 99 | Orange |
| AG133 | 20 | 0734 | 49 | 21.7 | 28.4 | 11.5 | 30 | 99 | Color |
| AG134 | 20 | 0743 | 51 | 21.7 | 28.4 | 11.5 | 30 | 99 | Red |
| AG135 | 20 | 0510–0810 | 15–59 | 21.7 | 28.4 | 11.5 | 30 | 99 | Visual |
| AG136 | 21 | 0410–0520 | 351–08 | 21.7 | 28.4 | 11.5 | 1 July | 99 | Visual |
| AG137 | 21 | 0420 | 353 | 21.7 | 28.4 | 11.5 | 1 | 99 | Color |
| AG138 | 21 | 0435 | 358 | 21.7 | 28.4 | 11.5 | 1 | 99 | Red |
| AG139 | 23 | 0508 | 347 | 21.7 | 29.3 | 11.4 | 2 | 100 | Red |
| AG140 | 23 | 0523 | 350 | 21.7 | 29.3 | 11.4 | 2 | 100 | Red |
| AG141 | 23 | 0538 | 355 | 21.7 | 29.3 | 11.4 | 2 | 100 | Color |
| AG142 | 23 | 0543 | 355 | 21.7 | 29.3 | 11.4 | 2 | 100 | Blue |
| AG143 | 23 | 0549 | 357 | 21.7 | 29.3 | 11.4 | 2 | 100 | Violet |
| AG144 | 23 | 0458–0556 | 345–359 | 21.7 | 29.3 | 11.4 | 2 | 100 | Visual |
| AG145 | 24 | 0440 | 331 | 21.7 | 30.1 | 11.2 | 2 | 101 | Blue |
| AG146 | 24 | 0500 | 336 | 21.7 | 30.1 | 11.2 | 2 | 101 | Violet |

| Log No. | TD (UT) | UT | CM, ° | Declination ⊕ (tilt), ° | Terminator, ° | Diameter, ″ | MD | $L_s$, ° | Observation type |
|---|---|---|---|---|---|---|---|---|---|
| 4129 | Apr. 24 | 0500 | 336 | 21.7 | 30.1 | 11.2 | 2 July | 101 | Infrared |
| AG147 | 24 | 0512 | 338 | 21.7 | 30.1 | 11.2 | 2 | 101 | Orange |
| 4130 | 24 | 0512 | 338 | 21.7 | 30.1 | 11.2 | 2 | 101 | Red |
| 4131 | 24 | 0520 | 341 | 21.7 | 30.1 | 11.2 | 2 | 101 | Orange |
| 4132 | 24 | 0530 | 343 | 21.7 | 30.1 | 11.2 | 2 | 101 | Blue |
| 4134 | 24 | 0715 | 10 | 21.7 | 30.1 | 11.2 | 2 | 101 | Blue |
| 4135 | 24 | 0724 | 10 | 21.7 | 30.1 | 11.2 | 2 | 101 | Orange |
| 4136 | 26 | 0631 | 339 | 22.0 | 30.1 | 11.0 | 3 | 102 | Blue |
| 4138 | 27 | 0344 | 289 | 22.0 | 30.1 | 11.0 | 4 | 102 | Blue |
| 4139 | 27 | 0355 | 294 | 22.0 | 30.1 | 11.0 | 4 | 102 | Violet |
| 4140 | 27 | 0408 | 296 | 22.0 | 30.1 | 11.0 | 4 | 102 | Green |
| 4141 | 27 | 0416 | 298 | 22.0 | 30.1 | 11.0 | 4 | 102 | Orange |
| 4142 | 27 | 0426 | 301 | 22.0 | 30.1 | 11.0 | 4 | 102 | Red |
| AG148 | 27 | 0438 | 303 | 22.0 | 30.1 | 11.0 | 4 | 102 | Orange |
| AG149 | 27 | 0450 | 306 | 22.0 | 30.1 | 11.0 | 4 | 102 | Blue |
| AG150 | 27 | 0507 | 311 | 22.0 | 30.1 | 11.0 | 4 | 102 | Blue |
| 4143 | 27 | 0510 | 311 | 22.0 | 30.1 | 11.0 | 4 | 102 | Orange |
| AG151 | 27 | 0512 | 311 | 22.0 | 30.1 | 11.0 | 4 | 102 | Color |
| 4144 | 27 | 0519 | 313 | 22.0 | 30.1 | 11.0 | 4 | 102 | Visual |
| AG152 | 27 | 0525 | 315 | 22.0 | 30.1 | 11.0 | 4 | 102 | Violet |
| AG153 | 27 | 0430 | 301 | 22.0 | 30.1 | 11.0 | 4 | 102 | Visual |
| 4146 | 28 | 0401 | 284 | 22.0 | 31.6 | 10.8 | 4 | 102 | Blue |
| 4147 | 28 | 0410 | 287 | 22.0 | 31.6 | 10.8 | 4 | 102 | Green |
| 4148 | 28 | 0419 | 289 | 22.0 | 31.6 | 10.8 | 4 | 102 | Orange |
| 4149 | 28 | 0428 | 292 | 22.0 | 31.6 | 10.8 | 4 | 102 | Red |
| AG154 | 28 | 0438–0602 | 294–313 | 22.0 | 31.6 | 10.8 | 4 | 102 | Visual |
| AG155 | 28 | 0505 | 301 | 22.0 | 31.6 | 10.8 | 4 | 102 | Color |
| AG156 | 28 | 0545 | 311 | 22.0 | 31.6 | 10.8 | 4 | 102 | Blue |
| AG157 | 28 | 0554 | 311 | 22.0 | 31.6 | 10.8 | 4 | 102 | Violet |
| 4151 | 28 | 0631 | 321 | 22.0 | 31.6 | 10.8 | 4 | 102 | Visual |
| 4152 | 29 | 0425 | 282 | 22.0 | 31.6 | 10.8 | 4–5 | 103 | Blue |
| 4153 | 29 | 0436 | 285 | 22.0 | 31.6 | 10.8 | 4–5 | 103 | Green |
| 4154 | 29 | 0446 | 287 | 22.0 | 31.6 | 10.8 | 4–5 | 103 | Orange |
| AG158 | 29 | 0702 | 319 | 22.0 | 31.6 | 10.8 | 4–5 | 103 | Orange |
| AG159 | 29 | 0715 | 324 | 22.0 | 31.6 | 10.8 | 4–5 | 103 | Color |
| AG160 | 29 | 0730 | 326 | 22.0 | 31.6 | 10.8 | 4–5 | 103 | Green |
| AG161 | 29 | 0738 | 329 | 22.0 | 31.6 | 10.8 | 4–5 | 103 | Green |
| AG162 | 29 | 0746 | 331 | 22.0 | 31.6 | 10.8 | 4–5 | 103 | Blue |
| AG163 | 29 | 0753 | 331 | 22.0 | 31.6 | 10.8 | 4–5 | 103 | Violet |
| AG164 | 29 | 0655–0822 | 319–338 | 22.0 | 31.6 | 10.8 | 4–5 | 103 | Visual |
| AG165 | 30 | 0645–0807 | 307–327 | 22.0 | 32.3 | 10.7 | 5 | 103 | Visual |
| AG166 | 30 | 0649 | 307 | 22.0 | 32.3 | 10.7 | 5 | 103 | Color |
| AG167 | 30 | 0710 | 312 | 22.0 | 32.3 | 10.7 | 5 | 103 | Blue |
| AG168 | 30 | 0717 | 315 | 22.0 | 32.3 | 10.7 | 5 | 103 | Violet |
| AG169 | 30 | 0737 | 319 | 22.0 | 32.3 | 10.7 | 5 | 103 | Red |
| AG170 | 30 | 0744 | 319 | 22.0 | 32.3 | 10.7 | 5 | 103 | Red |
| AG171 | 30 | 0754 | 322 | 22.0 | 32.3 | 10.7 | 5 | 103 | Green |
| AG172 | May 1 | 0549 | 283 | 22.0 | 32.3 | 10.7 | 5 | 104 | Green |

| Log No. | TD (UT) | UT | CM, ° | Declination ⊕ (tilt), ° | Terminator, ° | Diameter, " | MD | $L_s$, ° | Observation type |
|---|---|---|---|---|---|---|---|---|---|
| AG173 | May 1 | 0614 | 288 | 22.0 | 32.3 | 10.7 | 5 July | 104 | Blue |
| AG174 | 1 | 0619 | 291 | 22.0 | 32.3 | 10.7 | 5 | 104 | Violet |
| AG175 | 1 | 0624 | 291 | 22.0 | 32.3 | 10.7 | 5 | 104 | Color |
| AG176 | 1 | 0520 | 276 | 22.0 | 32.3 | 10.7 | 5 | 104 | Visual |
| AG177 | 2 | 0555–0653 | 277–289 | 22.0 | 32.3 | 10.5 | 6 | 104 | Visual |
| AG179 | 2 | 0615 | 281 | 22.0 | 32.3 | 10.5 | 6 | 104 | Color |
| AG178 | 2 | 0603 | 277 | 22.0 | 32.3 | 10.5 | 6 | 104 | Blue |
| AG180 | 6 | 0715 | 259 | 22.6 | 34.2 | 10.2 | 8 | 106 | Blue |
| AG181 | 6 | 0545–0725 | 236–261 | 22.6 | 34.2 | 10.2 | 8 | 106 | Visual |
| AG182 | 7 | 0735 | 254 | 22.6 | 34.2 | 10.2 | 8 | 107 | Visual |
| AG183 | 7 | 0740 | 254 | 22.6 | 34.2 | 10.2 | 8 | 107 | Blue |
| AG184 | 7 | 0744 | 254 | 22.6 | 34.2 | 10.2 | 8 | 107 | Violet |
| AG185 | 7 | 0755 | 259 | 22.6 | 34.2 | 10.2 | 8 | 107 | Orange |
| 4156 | 9 | 0422 | 187 | 22.6 | 34.2 | 10.0 | 9 | 107 | Red |
| 4157 | 9 | 0429 | 189 | 22.6 | 34.2 | 10.0 | 9 | 107 | Orange |
| 4158 | 9 | 0437 | 191 | 22.6 | 34.2 | 10.0 | 9 | 107 | Green |
| 4159 | 9 | 0445 | 194 | 22.6 | 34.2 | 10.0 | 9 | 107 | Blue |
| 4160 | 9 | 0453 | 194 | 22.6 | 34.2 | 10.0 | 9 | 107 | Violet |
| 4161 | 9 | 0415 | 187 | 22.6 | 34.2 | 10.0 | 9 | 107 | Visual |
| 4162 | 10 | 0502 | 187 | 22.6 | 35.2 | 9.8 | 10 | 108 | Orange |
| 4163 | 10 | 0520 | 192 | 22.6 | 35.2 | 9.8 | 10 | 108 | Green |
| 4164 | 10 | 0600 | 202 | 22.6 | 35.2 | 9.8 | 10 | 108 | Blue |
| 4165 | 10 | 0618 | 207 | 22.6 | 35.2 | 9.8 | 10 | 108 | Ultraviolet |
| 4166 | 10 | 0633 | 209 | 22.6 | 35.2 | 9.8 | 10 | 108 | Red |
| 4167 | 10 | 0735 | 226 | 22.6 | 35.2 | 9.8 | 10 | 108 | Violet |
| 4168 | 10 | 0450–0800 | 185–231 | 22.6 | 35.2 | 9.8 | 10 | 108 | Visual |
| 4169 | 11 | 0505 | 181 | 22.6 | 35.2 | 9.7 | 10 | 108 | Orange |
| 4170 | 11 | 0520 | 183 | 22.6 | 35.2 | 9.7 | 10 | 108 | Blue |
| 4172 | 16 | 0540 | 141 | 23.1 | 36.1 | 9.4 | 13 | 111 | Blue |
| 4173 | 16 | 0549 | 143 | 23.1 | 36.1 | 9.4 | 13 | 111 | Green |
| 4174 | 17 | 0547 | 134 | 23.1 | 36.1 | 9.4 | 13 | 111 | Red |
| 4175 | 17 | 0605 | 139 | 23.1 | 36.1 | 9.4 | 13 | 111 | Green |
| 4176 | 17 | 0623 | 141 | 23.1 | 36.1 | 9.4 | 13 | 111 | Blue |
| 4177 | 17 | 0335 | 102 | 23.1 | 36.1 | 9.4 | 13 | 111 | Visual |
| 4178 | 19 | 0357 | 88 | 23.1 | 36.1 | 9.2 | 14 | 112 | Blue |
| 4179 | 20 | 0332 | 72 | 23.1 | 37.3 | 9.1 | 14 | 112 | Orange |
| 4180 | 20 | 0410 | 81 | 23.1 | 37.3 | 9.1 | 14 | 112 | Blue |
| 4181 | 20 | 0420 | 84 | 23.1 | 37.3 | 9.1 | 14 | 112 | Green |
| 4182 | 22 | 0352 | 57 | 23.6 | 37.3 | 9.0 | 15 | 113 | Visual |
| 4183 | 26 | 0410–0551 | 24–49 | 23.6 | 38.1 | 8.7 | 17 | 115 | Visual |
| AG186 | 26 | 0505–0630 | 39–59 | 23.6 | 38.1 | 8.7 | 17 | 115 | Visual |
| 4184 | 28 | 0416 | 8 | 23.6 | 38.1 | 8.6 | 18 | 116 | Orange |
| 4185 | 28 | 0421 | 8 | 23.6 | 38.1 | 8.6 | 18 | 116 | Orange |
| 4186 | 28 | 0424 | 8 | 23.6 | 38.1 | 8.6 | 18 | 116 | Red |
| 4187 | 28 | 0428 | 10 | 23.6 | 38.1 | 8.6 | 18 | 116 | Blue |
| AG187 | 28 | 0430–0545 | 10–30 | 23.6 | 38.1 | 8.6 | 18 | 116 | Visual |
| 4188 | 28 | 0431 | 10 | 23.6 | 38.1 | 8.6 | 18 | 116 | Violet |
| 4189 | 28 | 0435 | 13 | 23.6 | 38.1 | 8.6 | 18 | 116 | Green |

| Log No. | TD (UT) | UT | CM, ° | Declination ⊕ (tilt), ° | Terminator, ° | Diameter, ″ | MD | $L_s$, ° | Observation type |
|---|---|---|---|---|---|---|---|---|---|
| 4190 | May 28 | 0451 | 15 | 23.6 | 38.1 | 8.6 | 18 July | 116 | Visual |
| AG188 | 28 | 0513 | 20 | 23.6 | 38.1 | 8.6 | 18 | 116 | Color |
| AG189 | 28 | 0530 | 25 | 23.6 | 38.1 | 8.6 | 18 | 116 | Blue |
| AG190 | 28 | 0537 | 28 | 23.6 | 38.1 | 8.6 | 18 | 116 | Violet |
| 4191 | 30 | 0615 | 18 | 24.0 | 38.1 | 8.5 | 19 | 117 | Visual |
| 4192 | 31 | 0357 | 335 | 24.0 | 38.1 | 8.5 | 20 | 118 | Visual |
| 4193 | June 1 | 0400 | 325 | 24.0 | 38.1 | 8.4 | 20 | 118 | Visual |
| 4194 | 1 | 0414 | 327 | 24.0 | 38.1 | 8.4 | 20 | 118 | Blue |
| 4195 | 1 | 0425 | 332 | 24.0 | 38.1 | 8.4 | 20 | 118 | Violet |
| 4196 | 2 | 0334 | 308 | 24.0 | 38.1 | 8.4 | 21 | 119 | Blue |
| 4197 | 2 | 0341 | 311 | 24.0 | 38.1 | 8.4 | 21 | 119 | Violet |
| 4198 | 2 | 0350 | 313 | 24.0 | 38.1 | 8.4 | 21 | 119 | Orange |
| 4199 | 2 | 0325 | 308 | 24.0 | 38.1 | 8.4 | 21 | 119 | Visual |
| 4200 | 5 | 0355 | 287 | 24.0 | 39.0 | 8.1 | 22 | 120 | Visual |
| 4201 | 5 | 0400 | 287 | 24.0 | 39.0 | 8.1 | 22 | 120 | Orange |
| 4202 | 5 | 0428 | 292 | 24.0 | 39.0 | 8.1 | 22 | 120 | Color |
| 4203 | 5 | 0553 | 314 | 24.0 | 39.0 | 8.1 | 22 | 120 | Blue |
| 4204 | 5 | 0604 | 316 | 24.0 | 39.0 | 8.1 | 22 | 120 | Violet |
| 4205 | 6 | 0450 | 290 | 24.0 | 39.0 | 8.1 | 23 | 120 | Blue |
| 4206 | 6 | 0458 | 292 | 24.0 | 39.0 | 8.1 | 23 | 120 | Violet |
| 4207 | 6 | 0445 | 290 | 24.0 | 39.0 | 8.1 | 23 | 120 | Visual |
| 4208a | 7 | 0458 | 282 | 24.0 | 39.0 | 8.0 | 23 | 121 | Visual |
| 4208b | 9 | 0505–0526 | 266–270 | 24.5 | 39.0 | 7.9 | 25 | 122 | Visual |
| 4209 | 10 | 0415 | 244 | 24.5 | 39.0 | 7.9 | 25 | 122 | Visual |
| 4210 | 10 | 0430 | 246 | 24.5 | 39.0 | 7.9 | 25 | 122 | Orange |
| 4211 | 10 | 0446 | 251 | 24.5 | 39.0 | 7.9 | 25 | 122 | Blue |
| 4212 | 10 | 0452 | 251 | 24.5 | 39.0 | 7.9 | 25 | 122 | Violet |
| 4213 | 10 | 0500 | 254 | 24.5 | 39.0 | 7.9 | 25 | 122 | Green |
| 4214 | 11 | 0408 | 232 | 24.5 | 39.5 | 7.8 | 25 | 123 | Green |
| 4215 | 11 | 0424 | 234 | 24.5 | 39.5 | 7.8 | 25 | 123 | Orange |
| 4216 | 11 | 0359 | 229 | 24.5 | 39.5 | 7.8 | 25 | 123 | Visual |
| 4217 | 12 | 0500 | 234 | 24.5 | 39.5 | 7.8 | 26 | 124 | Visual |
| 4218 | 13 | 0458 | 225 | 24.5 | 39.5 | 7.7 | 26 | 124 | Visual |
| 4219 | 13 | 0520 | 230 | 24.5 | 39.5 | 7.7 | 26 | 124 | Orange |
| AG191 | 15 | 0357 | 191 | 24.5 | 39.5 | 7.6 | 27 | 125 | Blue |
| AG192 | 15 | 0403 | 191 | 24.5 | 39.5 | 7.6 | 27 | 125 | Orange |
| AG193 | 15 | 0412 | 193 | 24.5 | 39.5 | 7.6 | 27 | 125 | Green |
| AG194 | 15 | 0426 | 198 | 24.5 | 39.5 | 7.6 | 27 | 125 | Violet |
| AG195 | 15 | 0433 | 198 | 24.5 | 39.5 | 7.6 | 27 | 125 | Blue |
| AG196 | 15 | 0438 | 201 | 24.5 | 39.5 | 7.6 | 27 | 125 | Color |
| AG197 | 15 | 0340–0450 | 186–203 | 24.5 | 39.5 | 7.6 | 27 | 125 | Visual |
| AG198 | 17 | 0355 | 172 | 24.5 | 39.5 | 7.5 | 28 | 126 | Visual |
| AG199 | 17 | 0428 | 179 | 24.5 | 39.5 | 7.5 | 28 | 126 | Blue |
| AG200 | 17 | 0437 | 181 | 24.5 | 39.5 | 7.5 | 28 | 126 | Violet |
| AG201 | 18 | 0346 | 160 | 24.5 | 39.5 | 7.5 | 29 | 125 | Blue |
| AG202 | 18 | 0351 | 160 | 24.5 | 39.5 | 7.5 | 29 | 125 | Violet |
| AG203 | 18 | 0400 | 162 | 24.5 | 39.5 | 7.5 | 29 | 125 | Orange |
| AG204 | 18 | 0409 | 165 | 24.5 | 39.5 | 7.5 | 29 | 126 | Green |

| Log No. | TD (UT) | UT | CM, ° | Declination ⊕ (tilt), ° | Terminator, ° | Diameter, " | MD | $L_s$, ° | Observation type |
|---|---|---|---|---|---|---|---|---|---|
| AG205 | June 18 | 0324 | 152 | 24.5 | 39.5 | 7.5 | 29 July | 126 | Visual |
| AG206 | 19 | 0430–0530 | 160–174 | 24.5 | 39.5 | 7.4 | 29 | 127 | Visual |
| AG207 | 19 | 0450 | 165 | 24.5 | 39.5 | 7.4 | 29 | 127 | Green |
| AG208 | 19 | 0508 | 170 | 24.5 | 39.5 | 7.4 | 29 | 127 | Blue |
| AG209 | 19 | 0512 | 170 | 24.5 | 39.5 | 7.4 | 29 | 127 | Violet |
| AG210 | 19 | 0518 | 172 | 24.5 | 39.5 | 7.4 | 29 | 127 | Orange |
| AG211 | 20 | 0425 | 150 | 24.5 | 39.5 | 7.4 | 30 | 127 | Blue |
| AG212 | 20 | 0428 | 150 | 24.5 | 39.5 | 7.4 | 30 | 127 | Violet |
| AG213 | 20 | 0431 | 150 | 24.5 | 39.5 | 7.4 | 30 | 127 | Green |
| AG214 | 20 | 0436 | 153 | 24.5 | 39.5 | 7.4 | 30 | 127 | Orange |
| AG215 | 20 | 0420 | 148 | 24.5 | 39.5 | 7.4 | 30 | 127 | Visual |
| AG216 | 21 | 0500 | 148 | 24.5 | 39.5 | 7.4 | 30 | 128 | Visual |
| AG217 | 21 | 0510 | 150 | 24.5 | 39.5 | 7.4 | 30 | 128 | Blue |
| AG218 | 21 | 0516 | 153 | 24.5 | 39.5 | 7.4 | 30 | 128 | Blue |
| AG219 | 21 | 0520 | 153 | 24.5 | 39.5 | 7.4 | 30 | 128 | Violet |
| AG220 | 23 | 0415 | 119 | 24.5 | 39.5 | 7.3 | 31 | 129 | Green |
| AG221 | 23 | 0425 | 121 | 24.5 | 39.5 | 7.3 | 31 | 129 | Color |
| AG222 | 23 | 0431 | 121 | 24.5 | 39.5 | 7.3 | 31 | 129 | Blue |
| AG223 | 23 | 0436 | 124 | 24.5 | 39.5 | 7.3 | 31 | 129 | Violet |
| AG224 | 23 | 0441 | 124 | 24.5 | 39.5 | 7.3 | 31 | 129 | Orange |
| AG225 | 23 | 0448 | 126 | 24.5 | 39.5 | 7.3 | 31 | 129 | Blue |
| AG226 | 23 | 0355–0510 | 114–131 | 24.5 | 39.5 | 7.3 | 31 | 129 | Visual |
| AG227 | 25 | 0430 | 102 | 24.5 | 39.5 | 7.3 | 1 Aug. | 130 | Visual |
| AG228 | 25 | 0441 | 104 | 24.5 | 39.5 | 7.2 | 1 | 130 | Blue |
| AG229 | 26 | 0445 | 97 | 24.5 | 39.5 | 7.2 | 2 | 130 | Visual |
| AG230 | 27 | 0330 | 68 | 25.0 | 39.9 | 7.1 | 2 | 131 | Visual |
| AG230a | 28 | 0416 | 70 | 25.0 | 39.9 | 7.1 | 3 | 131 | Visual |
| AG231 | 28 | 0434 | 73 | 25.0 | 39.9 | 7.1 | 3 | 131 | Blue |
| AG232 | 28 | 0438 | 75 | 25.0 | 39.9 | 7.1 | 3 | 131 | Violet |
| AG233 | 28 | 0443 | 75 | 25.0 | 39.9 | 7.1 | 3 | 131 | Green |
| AG234 | 28 | 0447 | 79 | 25.0 | 39.9 | 7.1 | 3 | 131 | Orange |
| AG235 | 29 | 0434 | 63 | 25.0 | 39.9 | 7.0 | 3 | 132 | Orange |
| AG236 | 29 | 0439 | 66 | 25.0 | 39.9 | 7.0 | 3 | 132 | Color |
| AG237 | 29 | 0444 | 66 | 25.0 | 39.9 | 7.0 | 3 | 132 | Blue |
| AG238 | 29 | 0453 | 68 | 25.0 | 39.9 | 7.0 | 3 | 132 | Violet |
| AG239 | 29 | 0420 | 61 | 25.0 | 39.9 | 7.0 | 3 | 132 | Visual |
| AG240 | 30 | 0338–0510 | 41–63 | 25.0 | 39.9 | 7.0 | 4 | 132 | Visual |
| AG241 | 30 | 0408 | 49 | 25.0 | 39.9 | 7.0 | 4 | 132 | Orange |
| AG242 | 30 | 0429 | 54 | 25.0 | 39.9 | 7.0 | 4 | 132 | Green |
| AG243 | 30 | 0439 | 56 | 25.0 | 39.9 | 7.0 | 4 | 132 | Blue |
| AG244 | 30 | 0455 | 61 | 25.0 | 39.9 | 7.0 | 4 | 132 | Color |
| AG245 | July 2 | 0343 | 22 | 25.0 | 39.9 | 7.0 | 5 | 133 | Orange |
| AG246 | 2 | 0350 | 24 | 25.0 | 39.9 | 7.0 | 5 | 133 | Color |
| AG247 | 2 | 0356 | 27 | 25.0 | 39.9 | 7.0 | 5 | 133 | Blue |
| AG248 | 2 | 0402 | 27 | 25.0 | 39.9 | 7.0 | 5 | 133 | Violet |
| AG249 | 2 | 0407 | 29 | 25.0 | 39.9 | 7.0 | 5 | 133 | Green |
| AG250 | 2 | 0335 | 22 | 25.0 | 39.9 | 7.0 | 5 | 133 | Visual |
| 4222 | 8 | 0331 | 321 | 25.0 | 39.9 | 6.7 | 8 | 136 | Visual |

| Log No. | TD (UT) | UT | CM, ° | Declination ⊕ (tilt), ° | Terminator, ° | Diameter, ″ | MD | $L_s$, ° | Observation type |
|---|---|---|---|---|---|---|---|---|---|
| 4223 | July 8 | 0358 | 329 | 25.0 | 39.9 | 6.7 | 8 Aug. | 136 | Integrated |
| 4224 | 8 | 0414 | 331 | 25.0 | 39.9 | 6.7 | 8 | 136 | Orange |
| 4225 | 8 | 0418 | 334 | 25.0 | 39.9 | 6.7 | 8 | 136 | Blue |
| 4226 | 8 | 0422 | 334 | 25.0 | 39.9 | 6.7 | 8 | 136 | Violet |
| AG253 | 9 | 0352 | 317 | 25.0 | 39.9 | 6.7 | 9 | 136 | Green |
| AG254 | 9 | 0358 | 319 | 25.0 | 39.9 | 6.7 | 9 | 136 | Orange |
| AG255 | 9 | 0404 | 319 | 25.0 | 39.9 | 6.7 | 9 | 136 | Blue |
| AG256 | 9 | 0408 | 321 | 25.0 | 39.9 | 6.7 | 9 | 136 | Violet |
| AG257 | 9 | 0330 | 312 | 25.0 | 39.9 | 6.7 | 9 | 136 | Visual |
| 4227 | 9 | 0428 | 326 | 25.0 | 39.9 | 6.7 | 9 | 136 | Visual |
| 4228 | 10 | 0412 | 312 | 25.0 | 39.9 | 6.7 | 9 | 137 | Visual |
| 4230 | 11 | 0358 | 300 | 25.0 | 39.6 | 6.6 | 10 | 137 | Visual |
| AG258 | 11 | 0410–0515 | 302–319 | 25.0 | 39.6 | 6.6 | 10 | 137 | Visual |
| 4231 | 12 | 0401 | 290 | 25.0 | 39.6 | 6.6 | 10 | 138 | Visual |
| AG259 | 13 | 0310 | 268 | 25.0 | 39.6 | 6.5 | 11 | 138 | Visual |
| AG260 | 13 | 0323 | 270 | 25.0 | 39.6 | 6.5 | 11 | 138 | Blue |
| AG261 | 13 | 0325 | 273 | 25.0 | 39.6 | 6.5 | 11 | 138 | Blue |
| 4232 | 13 | 0327–0459 | 273–295 | 25.0 | 39.6 | 6.5 | 11 | 138 | Visual |
| AG262 | 13 | 0328 | 273 | 25.0 | 39.6 | 6.5 | 11 | 138 | Violet |
| AG263 | 13 | 0332 | 273 | 25.0 | 39.6 | 6.5 | 11 | 138 | Color |
| AG264 | 13 | 0336 | 275 | 25.0 | 39.6 | 6.5 | 11 | 138 | Orange |
| AG265 | 13 | 0340 | 275 | 25.0 | 39.6 | 6.5 | 11 | 138 | Green |
| AG266 | 13 | 0348 | 278 | 25.0 | 39.6 | 6.5 | 11 | 138 | Orange |
| 4233 | 13 | 0433 | 288 | 25.0 | 39.6 | 6.5 | 11 | 138 | Green |
| 4234 | 13 | 0437 | 290 | 25.0 | 39.6 | 6.5 | 11 | 138 | Blue |
| 4235 | 13 | 0445 | 292 | 25.0 | 39.6 | 6.5 | 11 | 138 | Violet |
| 4236 | 13 | 0453 | 292 | 25.0 | 39.6 | 6.5 | 11 | 138 | Orange |
| AG267 | 14 | 0344 | 266 | 25.0 | 39.6 | 6.5 | 11 | 139 | Visual |
| 4237 | 14 | 0405 | 273 | 25.0 | 39.6 | 6.5 | 11 | 139 | Visual |
| AG268 | 14 | 0413 | 273 | 25.0 | 39.6 | 6.5 | 11 | 139 | Blue |
| AG269 | 14 | 0418 | 275 | 25.0 | 39.6 | 6.5 | 11 | 139 | Violet |
| 4238 | 15 | 0331 | 253 | 25.0 | 39.6 | 6.5 | 12 | 139 | Visual |
| AG272 | 15 | 0419 | 266 | 25.0 | 39.6 | 6.5 | 12 | 139 | Blue |
| AG273 | 15 | 0424 | 266 | 25.0 | 39.6 | 6.5 | 12 | 139 | Orange |
| AG274 | 15 | 0432 | 268 | 25.0 | 39.6 | 6.5 | 12 | 139 | Violet |
| AG275 | 15 | 0435 | 270 | 25.0 | 39.6 | 6.5 | 12 | 139 | Green |
| AG276 | 15 | 0320–0500 | 251–275 | 25.0 | 39.6 | 6.5 | 12 | 139 | Visual |
| AG277 | 16 | 0400 | 251 | 25.0 | 39.6 | 6.5 | 12 | 140 | Blue |
| AG278 | 16 | 0407 | 253 | 25.0 | 39.6 | 6.5 | 12 | 140 | Violet |
| AG279 | 16 | 0418 | 256 | 25.0 | 39.6 | 6.5 | 12 | 140 | Color |
| AG280 | 16 | 0345 | 249 | 25.0 | 39.6 | 6.5 | 12 | 140 | Visual |
| AG281 | 19 | 0354 | 219 | 24.6 | 39.6 | 6.4 | 14 | 141 | Blue |
| AG282 | 19 | 0358 | 222 | 24.6 | 39.6 | 6.4 | 14 | 141 | Violet |
| AG283 | 19 | 0404 | 222 | 24.6 | 39.6 | 6.4 | 14 | 141 | Orange |
| AG284 | 19 | 0332 | 213 | 24.6 | 39.6 | 6.4 | 14 | 141 | Visual |
| AG290 | 20 | 0330 | 205 | 24.6 | 39.6 | 6.4 | 14 | 142 | Blue |
| AG291 | 20 | 0333 | 205 | 24.6 | 39.6 | 6.4 | 14 | 142 | Violet |
| AG292 | 20 | 0337 | 207 | 24.6 | 39.6 | 6.4 | 14 | 142 | Orange |

| Log No. | TD (UT) | UT | CM, ° | Declination ⊕ (tilt), ° | Terminator, ° | Diameter, " | MD | $L_s$, ° | Observation type |
|---|---|---|---|---|---|---|---|---|---|
| AG293 | July 20 | 0341 | 207 | 24.6 | 39.6 | 6.4 | 14 Aug. | 142 | Blue |
| 4239 | 20 | 0341 | 207 | 24.6 | 39.6 | 6.4 | 14 | 142 | Visual |
| AG294 | 20 | 0346 | 210 | 24.6 | 39.6 | 6.4 | 14 | 142 | Green |
| AG295 | 20 | 0320 | 202 | 24.6 | 39.6 | 6.4 | 14 | 142 | Visual |
| AG301 | 21 | 0312 | 190 | 24.6 | 39.6 | 6.3 | 15 | 142 | Orange |
| AG302 | 21 | 0305 | 190 | 24.6 | 39.6 | 6.3 | 15 | 142 | Visual |
| 4240 | 21 | 0334 | 195 | 24.6 | 39.6 | 6.3 | 15 | 142 | Visual |
| 4243 | Aug. 7 | 0300 | 22 | 23.1 | 38.0 | 5.9 | 24 | 151 | Visual |
| 4248 | 25 | 0335 | 216 | 20.8 | 36.3 | 5.5 | 3 Sept. | 161 | Visual |
| 4390 | Oct. 12 | 0224 | 87 | 9.6 | 30.2 | 4.9 | 1 Oct. | 188 | Visual |

# APPENDIX B

## Physical Data for Observations of Mars 1964–1965 Apparition

A useful ephemeris for physical observations of Mars is compiled by the Table Mountain Observatory staff at the beginning of each Martian apparition from the *American Ephemeris and Nautical Almanac.* The selected data aid observers planning an observational program, active observers engaged at the telescope, and later data reduction. The ephemerides for Mars are given for $0^h$ Universal Time (UT) and reduced or computed in the most useful form for the observer.

Explanation of the tabulated columns from left to right follows:

1. The terrestrial date (TD) begins at $0^h$ UT.
2. The Martian date (MD) is important for cognizance of seasonal change. A Martian local seasonal date is given for each observation. This dating system is computed to closely coincide with the true northern hemisphere Martian seasonal aspect as dictated by the Sun's position in the sky relative to the planet Mars; the MD is determined by the planetocentric longitude of the Sun ($L_s$) and is measured along the orbital plane from the vernal equinox. In this system, the vernal equinox occurs when the subsolar point coincides with the Martian equator ($D_s = 0$) and the planetocentric longitude of the Sun equals 0° ($L_s = 0$). The summer solstice therefore occurs 90° later when the Sun is highest in the Martian sky with a subsolar point located at +24° areographic latitude and a planetocentric longitude of 90° ($L_s = 90°$); and similarly for the two remaining Martian seasons of fall and winter. It will be noted that each Martian date lasts for a period of two Martian days, and in some cases it covers three Martian days; this is caused by the fact that the Mars year is nearly twice as long as the Earth year.
3. The declination of the planet Earth ($D_E$) in degrees as seen from the center of Mars is tabulated at approximately half-degree intervals. This defines the axial tilt of the Martian globe relative to the terrestrial observer, where + indicates that the North Pole is tilted toward the observer, − indicates that the South Pole is tilted toward the observer.
4. The diameter of the disk of Mars is given in seconds of subtended arc.
5. The percentage of the disk illuminated ($k$) defines the apparent phase of the planet, and lends perspective to the visible surface detail.
6. The unilluminated portion of the Martian disk ($i$), given in degrees, aids in positioning the terminator in longitude on reference maps for the time of observation, and, combined with the position angle of the greatest defect of illumination, defines the terminator boundary of the visible surface.
7. The defect of illumination is here converted to mm relative to a 42-mm-diameter disk drawing. These data, combined with the position angle of the greatest defect of illumination, uniquely define the terminator position of the disk drawing. The scale of the 42-mm-diameter disk drawing is 1 mm = 100 miles (160 km).
8. The greatest defect of illumination position angle is given in degrees measured eastward from the north point of the disk.
9. The North Pole position angle is given in degrees measured eastward from the north point of the disk.
10. The Martian longitude in degrees on the Central Meridian (CM) at $0^h$ UT is tabulated daily. From this table the Martian longitude at the time of observation may be calculated by employing the known rotation rate of Mars: $2\overset{\circ}{.}4$ longitude per 10 min of time, or $14\overset{\circ}{.}6$/hr. Appendix C is useful here.

| TD | MD | Declination ⊕, ° | Diameter, ″ | % Illuminated disk | Unilluminated disk, ° | Defect illumination* | Defect position ∠, ° | North Pole, ° | CM $0^h$ UT, ° |
|---|---|---|---|---|---|---|---|---|---|
| 1964 | | | | | | | | | |
| Sept. 10 | 19 Mar. | +11.91 | 4.69 | 0.934 | 29.81 | 2.8mm | 281.84 | 348.96 | 201.45 |
| 11 | 19 | | | | | | | | 191.75 |
| 12 | 20 | | 4.71 | | 30.07 | | 282.31 | 349.70 | 182.06 |
| 13 | 20 | | | | | | | | 172.37 |
| 14 | 21 | 12.79 | 4.74 | | | | 282.77 | 350.44 | 162.68 |
| 15 | 21 | | | | | | | | 152.99 |
| 16 | 22 | 13.22 | 4.77 | | 30.58 | | 283.22 | 351.17 | 143.29 |
| 17 | 22 | | | | | | | | 133.60 |
| 18 | 23 | | 4.80 | 0.929 | | | 283.66 | 351.91 | 123.91 |
| 19 | 23 | | | | | | | | 114.22 |
| 20 | 24 | 14.05 | 4.83 | | 31.08 | 3.0 | 284.09 | 352.65 | 104.53 |
| 21 | 24 | | | | | | | | 94.84 |
| 22 | 25 | 14.45 | 4.86 | | | | 284.51 | 353.38 | 85.15 |
| 23 | 25 | | | | | | | | 75.46 |
| 24 | 26 | 14.85 | 4.89 | | 31.57 | | 284.92 | 354.12 | 65.77 |
| 25 | 26 | | | | | | | | 56.08 |
| 26 | 27 | 15.23 | 4.92 | | | | 285.32 | 354.85 | 46.39 |
| 27 | 27 | | | | | | | | 36.70 |
| 28 | 28 | 15.61 | 4.96 | | 32.05 | | 285.71 | 355.58 | 27.02 |
| 29 | 28 | | | | | | | | 17.33 |
| 30 | 29 | 15.91 | 4.99 | | | 3.3 | 286.09 | 356.31 | 7.64 |
| Oct. 1 | 29 | | | | | | | | 357.95 |
| 2 | 30 | 16.34 | 5.03 | | 32.52 | | | 357.04 | 348.27 |
| 3 | 30 | | | | | | | | 338.58 |
| 4 | 31 | 16.69 | 5.07 | | | | 286.82 | 357.76 | 328.89 |
| 5 | 31 | | | | | | | | 319.21 |
| 6 | 31 | 17.63 | 5.10 | 0.919 | | | | 358.49 | 309.53 |
| 7 | 1 Apr. | | | | | | | | 299.84 |
| 8 | 1 | | 5.14 | | 33.20 | | 287.50 | 359.21 | 290.16 |
| 9 | 2 | | | | | | | | 280.48 |
| 10 | 2 | 17.68 | 5.18 | | | 3.5 | | 359.92 | 270.79 |
| 11 | 3 | | | | | | | | 261.11 |
| 12 | 3 | 18.00 | 5.23 | | | | 288.14 | 0.63 | 251.43 |
| 13 | 4 | | | | | | | | 241.75 |
| 14 | 4 | | 5.27 | | | | | 1.34 | 232.07 |
| 15 | 5 | | | | | | | | 222.40 |
| 16 | 5 | 18.59 | 5.31 | | 34.04 | | 288.74 | 2.04 | 212.72 |
| 17 | 6 | | | | | | | | 203.04 |
| 18 | 6 | | 5.36 | | | | 289.03 | 2.74 | 193.37 |
| 19 | 6–7 | | | | | | | | 183.69 |
| 20 | 7 | 19.15 | 5.41 | | | 3.6 | | 3.43 | 174.02 |
| 21 | 7–8 | | | | | | | | 164.35 |
| 22 | 8 | | 5.45 | | | | 289.56 | 4.12 | 154.68 |
| 23 | 9 | | | | | | | | 145.01 |
| 24 | 9 | 19.66 | 5.50 | | | | | 4.80 | 135.34 |
| 25 | 10 | | | | | | | | 125.67 |

*Defect of illumination in mm for a 42-mm diameter disk drawing.

| TD | MD | Declination ⊕, ° | Diameter, ″ | % Illuminated disk | Unilluminated disk, ° | Defect illumination* | Defect position ∠, ° | North Pole, ° | CM $0^h$ UT, ° |
|---|---|---|---|---|---|---|---|---|---|
| Oct. 26 | 10 Apr. | | 5.56 | | | | 290.06 | 5.47 | 116.00 |
| 27 | 11 | | | | | | | | 106.34 |
| 28 | 11 | +20.14 | 5.61 | 0.909 | 35.16 | | | 6.14 | 96.67 |
| 29 | 11 | | | | | | | | 87.01 |
| 30 | 12 | | 5.66 | | | 3.8 | 290.51 | 6.81 | 77.35 |
| 31 | 12 | | | | | | | | 67.69 |
| Nov. 1 | 13 | 20.57 | 5.72 | | | | | 7.46 | 58.03 |
| 2 | 13 | | | | | | | | 48.37 |
| 3 | 14 | | 5.78 | | | | 290.92 | 8.11 | 38.72 |
| 4 | 14 | | | | | | | | 29.06 |
| 5 | 15 | 20.96 | 5.84 | | | | | 8.75 | 19.41 |
| 6 | 15 | | | | | | | | 9.76 |
| 7 | 16 | | 5.90 | | | | | 9.38 | 0.12 |
| 8 | 16 | | | | | | | | 350.47 |
| 9 | 17 | | 5.96 | | 36.04 | 4.0 | 291.46 | 10.01 | 340.83 |
| 10 | 17 | | | | | | | | 331.19 |
| 11 | 17–18 | 21.47 | 6.03 | | | | | 10.62 | 321.55 |
| 12 | 18 | | | | | | | | 311.91 |
| 13 | 19 | | 6.10 | | | | | 11.32 | 302.28 |
| 14 | 19 | | | | | | | | 292.65 |
| 15 | 19 | | 6.17 | | | | 291.91 | 11.83 | 283.02 |
| 16 | 20 | | | | | | | | 273.39 |
| 17 | 20 | | 6.24 | | | | | 12.41 | 263.77 |
| 18 | 21 | | | | | | | | 254.15 |
| 19 | 21 | 22.02 | 6.31 | | 36.55 | 4.1 | | 12.99 | 244.53 |
| 20 | 22 | | | | | | | | 234.91 |
| 21 | 22 | | 6.39 | | | | | 13.56 | 225.30 |
| 22 | 23 | | | | | | | | 215.69 |
| 23 | 23 | | 6.47 | | | | | 14.12 | 206.09 |
| 24 | 24 | | | | | | | | 196.48 |
| 25 | 24 | | 6.55 | | | | | 14.66 | 186.88 |
| 26 | 25 | | | | | | | | 177.29 |
| 27 | 25 | | 6.63 | | | | 292.54 | 15.20 | 167.69 |
| 28 | 25–26 | | | | | | | | 158.10 |
| 29 | 26 | | 6.72 | 0.900 | | 4.2 | | 15.72 | 148.52 |
| 30 | 26 | | | | | | | | 138.94 |
| Dec. 1 | 27 | 22.54 | 6.81 | | 36.79 | | | 16.24 | 129.36 |
| 2 | 27 | | | | | | | | 119.79 |
| 3 | 28 | 22.60 | 6.90 | | | | | 16.74 | 110.22 |
| 4 | 28 | | | | | | | | 100.65 |
| 5 | 29 | | 7.00 | | | | | 17.22 | 91.09 |
| 6 | 29 | | | | | | | | 81.53 |
| 7 | 30 | | 7.10 | | | | | 17.70 | 71.98 |
| 8 | 30 | | | | | | | | 62.43 |
| 9 | 1 May | 22.72 | 7.20 | | | 4.1 | | 18.16 | 52.89 |
| 10 | 1 | | | | | | | | 43.35 |

*Defect of illumination in mm for a 42-mm diameter disk drawing.

| TD | MD | Declination ⊕, ° | Diameter, ″ | % Illuminated disk | Unilluminated disk, ° | Defect illumination* | Defect position ∠, ° | North Pole, ° | CM $0^h$ UT, ° |
|---|---|---|---|---|---|---|---|---|---|
| Dec. 11 | 1 May | | 7.30 | | | | | 18.61 | 33.82 |
| 12 | 2 | | | | | | | | 24.30 |
| 13 | 2 | | 7.41 | | | | | 19.04 | 14.77 |
| 14 | 3 | | | | | | | | 5.26 |
| 15 | 3 | +22.77 | 7.52 | | | | 292.88 | 19.46 | 355.75 |
| 16 | 4 | | | | | | | | 346.24 |
| 17 | 4 | | 7.64 | | | | | 19.87 | 336.74 |
| 18 | 5 | | | | | | | | 327.25 |
| 19 | 5 | | 7.76 | | 36.15 | 4.0 | | 20.26 | 317.76 |
| 20 | 6 | | | | | | | | 308.28 |
| 21 | 6 | | 7.88 | | 35.98 | | | 20.64 | 298.80 |
| 22 | 6 | | | | | | | | 289.33 |
| 23 | 7 | | 8.01 | | | | | 21.00 | 279.87 |
| 24 | 7 | | | | | | | | 270.41 |
| 25 | 8 | 22.72 | 8.14 | | | | | | 260.96 |
| 26 | 8 | | | | | | | | 251.52 |
| 27 | 9 | 22.69 | 8.27 | | | | | 21.67 | 242.09 |
| 28 | 9 | | | | | | | | 232.66 |
| 29 | 10 | 22.66 | 8.41 | | | 3.8 | | | 223.24 |
| 30 | 10 | | | | | | | | 213.83 |
| 31 | 11 | 22.62 | 8.55 | 0.911 | 34.78 | | 292.59 | 22.28 | 204.42 |
| 1965 | | | | | | | | | |
| Jan. 1 | 11 | | | | | | | | 195.03 |
| 2 | 11 | 22.58 | 8.70 | | | | | 22.56 | 185.64 |
| 3 | 12 | | | | | | | | 176.26 |
| 4 | 12 | | 8.85 | | | | | 22.82 | 166.89 |
| 5 | 13 | | | | | | | | 157.53 |
| 6 | 13 | | 9.00 | | 33.73 | | | 23.07 | 148.18 |
| 7 | 14 | | | | | | | | 138.83 |
| 8 | 14 | | 9.16 | | | 3.4 | | | 129.50 |
| 9 | 15 | | | | | | | | 120.17 |
| 10 | 15 | | 9.32 | 0.920 | 32.86 | | | 23.50 | 110.86 |
| 11 | 15–16 | | | | | | | | 101.55 |
| 12 | 16 | | 9.49 | | | | 292.00 | | 92.25 |
| 13 | 17 | | | | | | | | 82.97 |
| 14 | 17 | | 9.66 | | 31.85 | | | | 73.69 |
| 15 | 17 | | | | | | | | 64.43 |
| 16 | 18 | | 9.84 | | | | | 24.01 | 55.17 |
| 17 | 18 | | | | | | | | 45.93 |
| 18 | 19 | | 10.02 | 0.930 | 30.70 | 2.9 | 291.57 | | 36.70 |
| 19 | 19 | | | | | | | | 27.48 |
| 20 | 20 | | 10.20 | | | | | | 18.27 |
| 21 | 20 | | | | | | | | 9.07 |
| 22 | 20–21 | 22.06 | 10.39 | | 29.37 | | | | 359.88 |
| 23 | 21 | | | | | | | | 350.71 |
| 24 | 21 | | 10.58 | | 28.65 | | 291.01 | | 341.55 |

*Defect of illumination in mm for a 42-mm diameter disk drawing.

| TD | MD | Declination ⊕, ° | Diameter, " | % Illuminated disk | Unilluminated disk, ° | Defect illumination* | Defect position ∠, ° | North Pole, ° | CM $0^h$ UT, ° |
|---|---|---|---|---|---|---|---|---|---|
| Jan. 25 | 22 May | | 12.71 | | | | | | 332.40 |
| 26 | 22 | | 10.77 | 0.942 | 27.87 | | | | 323.26 |
| 27 | 23 | | | | | | | | 314.14 |
| 28 | 23 | | 10.96 | | | 2.3 | 290.55 | 24.48 | 305.02 |
| 29 | 24 | | | | | | | | 295.93 |
| 30 | 24 | | 11.16 | | 26.18 | | | | 286.84 |
| 31 | 25 | | | | | | | | 277.77 |
| Feb. 1 | 25 | | 11.36 | 0.952 | 25.27 | | 289.99 | | 268.71 |
| 2 | 26 | | | | | | | | 259.67 |
| 3 | 26 | | 11.56 | | 24.30 | | | | 250.64 |
| 4 | 26–27 | | | | | | | | 241.62 |
| 5 | 27 | | 11.76 | | 23.28 | | | | 232.62 |
| 6 | 27 | | | | | | | | 223.63 |
| 7 | 28 | | 11.95 | 0.963 | 22.20 | 1.5 | 288.92 | | 214.65 |
| 8 | 28 | | | | | | | | 205.69 |
| 9 | 29 | | 12.15 | | 21.08 | | 288.47 | 24.12 | 196.74 |
| 10 | 29 | | | | | | | | 187.81 |
| 11 | 30 | +21.57 | 12.34 | 0.970 | 19.91 | | 287.97 | 23.98 | 178.89 |
| 12 | 30 | | | | | | | | 169.98 |
| 13 | 31 | | 12.53 | | 18.68 | | 287.38 | | 161.08 |
| 14 | 31 | | | | | | | | 152.20 |
| 15 | 1 June | | | | 17.41 | | 286.71 | 23.61 | 143.34 |
| 16 | 1 | | | | | | | | 134.48 |
| 17 | 1 | 21.47 | 12.89 | 0.980 | 16.09 | 0.8 | 285.92 | | 125.64 |
| 18 | 2 | | | | | | | | 116.81 |
| 19 | 2 | | 13.05 | | 14.73 | | 284.98 | | 107.99 |
| 20 | 3 | | | | | | | | 99.18 |
| 21 | 3 | | 13.21 | | 13.32 | | 283.83 | 22.87 | 90.39 |
| 22 | 4 | | | | | | | | 81.61 |
| 23 | 4 | 21.39 | 13.36 | | 11.88 | | 282.40 | | 72.84 |
| 24 | 5 | | | | | | | | 64.07 |
| 25 | 5 | | 13.49 | 0.992 | 10.40 | | 280.56 | 22.27 | 55.32 |
| 26 | 5–6 | | | | | | | | 46.58 |
| 27 | 6 | | 13.61 | | 8.90 | 0.3 | 278.10 | 21.93 | 37.84 |
| 28 | 6 | | | | | | | | 29.12 |
| Mar. 1 | 7 | | 13.72 | | 7.39 | | 274.63 | 21.58 | 20.40 |
| 2 | 7 | | | | | | | | 11.69 |
| 3 | 8 | | 13.81 | | 5.89 | | 269.38 | | 2.98 |
| 4 | 8 | | | | | | | | 354.28 |
| 5 | 9 | 21.28 | 13.89 | | 4.45 | | 260.65 | 20.82 | 345.59 |
| 6 | 9 | | | | | | | | 336.90 |
| 7 | 10 | | 13.94 | | 3.19 | | 244.37 | 20.43 | 328.21 |
| 8 | 10 | | | | | | | | 319.52 |
| 9 | 11 | | 13.98 | 1.000 | 2.43 | 0.0 | 213.48 | 20.02 | 310.84 |
| 10 | 11 | | | | | | | | 302.15 |
| 11 | 12 | | 14.00 | 0.999 | 2.68 | | 175.75 | 19.61 | 293.47 |

*Defect of illumination in mm for a 42-mm diameter disk drawing.

| TD | MD | Declination ⊕, ° | Diameter, ″ | % Illuminated disk | Unilluminated disk, ° | Defect illumination* | Defect position ∠, ° | North Pole, ° | CM $0^h$ UT, ° |
|---|---|---|---|---|---|---|---|---|---|
| Mar. 12 | 12 June | | | | | | | | 284.78 |
| 13 | 12 | | 14.00 | | 3.73 | | 152.17 | 19.19 | 276.09 |
| 14 | 13 | | | | | | | | 267.40 |
| 15 | 13 | | 13.98 | | 5.11 | | 140.01 | 18.78 | 258.71 |
| 16 | 14 | | | | | | | | 250.01 |
| 17 | 14 | +21.19 | 13.95 | | 6.61 | | 133.14 | 18.37 | 241.31 |
| 18 | 15 | | | | | | | | 232.60 |
| 19 | 15 | 21.18 | 13.89 | | 8.14 | 0.2 | 128.80 | 17.96 | 223.89 |
| 20 | 16 | | | | | | | | 215.17 |
| 21 | 16 | | 13.82 | | 9.68 | | 125.82 | 17.57 | 206.44 |
| 22 | 17 | | | | | | | | 197.70 |
| 23 | 17 | | 13.74 | | 11.20 | | 123.63 | 17.19 | 188.96 |
| 24 | 18 | | | | | | | | 180.20 |
| 25 | 18 | 21.18 | 13.64 | 0.988 | 12.71 | | 121.96 | 16.82 | 171.44 |
| 26 | 19 | | | | | | | | 162.67 |
| 27 | 19 | 21.19 | 13.52 | | 14.19 | | 120.63 | 16.47 | 153.88 |
| 28 | 19 | | | | | | | | 145.08 |
| 29 | 20 | | 13.39 | | 15.63 | 0.8 | 119.54 | 16.14 | 136.28 |
| 30 | 20 | | | | | | | | 127.46 |
| 31 | 21 | 21.22 | 13.26 | 0.978 | 17.03 | | 118.63 | 15.84 | 118.62 |
| April 1 | 21 | | | | | | | | 109.78 |
| 2 | 22 | | 13.11 | | 18.39 | | 117.87 | 15.56 | 100.92 |
| 3 | 22 | | | | | | | | 92.05 |
| 4 | 23 | | 12.95 | | 19.70 | | 117.21 | 15.31 | 83.16 |
| 5 | 23 | | | | | | | | 74.26 |
| 6 | 24 | 21.31 | 12.79 | 0.967 | 20.97 | | 116.64 | 15.08 | 65.35 |
| 7 | 24 | | | | | | | | 56.42 |
| 8 | 25 | | 12.62 | | 22.18 | 1.6 | | 14.88 | 47.48 |
| 9 | 25 | | | | | | | | 38.52 |
| 10 | 25 | 21.40 | 12.44 | | 23.35 | | 115.71 | | 29.55 |
| 11 | 26 | | | | | | | | 20.57 |
| 12 | 26 | | 12.27 | 0.955 | 24.46 | | | 14.57 | 11.57 |
| 13 | 27 | | | | | | | | 2.56 |
| 14 | 27 | 21.52 | 12.09 | | 25.53 | | 114.99 | | 353.53 |
| 15 | 28 | | | | | | | | 344.49 |
| 16 | 28 | | 11.91 | 0.947 | 26.54 | | | | 335.44 |
| 17 | 29 | | | | | | | | 326.37 |
| 18 | 29 | 21.67 | 11.73 | | 27.51 | 2.4 | 114.43 | | 317.28 |
| 19 | 30 | | | | | | | | 308.19 |
| 20 | 30 | | 11.54 | | 28.43 | | | 14.30 | 299.08 |
| 21 | 1 July | | | | | | | | 289.96 |
| 22 | 1 | | 11.36 | 0.936 | 29.30 | | 113.99 | | 280.82 |
| 23 | 2 | | | | | | | | 271.67 |
| 24 | 2 | | 11.18 | | 30.13 | | | | 262.51 |
| 25 | 3 | | | | | | | | 253.34 |
| 26 | 3 | 22.03 | 11.00 | 0.929 | | | | | 244.15 |
| 27 | 4 | | | | | | | | 234.95 |

*Defect of illumination in mm for a 42-mm diameter disk drawing.

| TD | MD | Declination ⊕, ° | Diameter, " | % Illuminated disk | Unilluminated disk, ° | Defect illumination* | Defect position ∠, ° | North Pole, ° | CM $0^h$ UT, ° |
|---|---|---|---|---|---|---|---|---|---|
| Apr. 28 | 4 July | | 10.83 | | 31.64 | 3.1 | 113.53 | | 225.74 |
| 29 | 4–5 | | | | | | | | 216.52 |
| 30 | 5 | | 10.66 | | 32.34 | | | 14.60 | 207.28 |
| May 1 | 5 | | | | | | | | 198.03 |
| 2 | 6 | | 10.48 | 0.919 | | | | | 188.77 |
| 3 | 6 | | | | | | | | 179.50 |
| 4 | 7 | | 10.32 | | 33.60 | | | | 170.22 |
| 5 | 7 | | | | | | | | 160.93 |
| 6 | 8 | +22.58 | 10.15 | | 34.18 | | | 15.07 | 151.62 |
| 7 | 8 | | | | | | | | 142.31 |
| 8 | 9 | | 9.99 | | | 3.7 | | | 132.98 |
| 9 | 9 | | | | | | | | 123.65 |
| 10 | 10 | | 9.84 | 0.908 | 35.22 | | | 15.50 | 114.30 |
| 11 | 10 | | | | | | | | 104.95 |
| 12 | 11 | | 9.68 | | | | | | 95.58 |
| 13 | 11 | | | | | | | | 86.21 |
| 14 | 12 | 23.07 | 9.53 | | 36.12 | | | 16.01 | 76.82 |
| 15 | 12 | | | | | | | | 67.43 |
| 16 | 13 | | 9.39 | | | | | | 58.03 |
| 17 | 13 | | | | | | | | 48.61 |
| 18 | 13 | | 9.24 | | | 4.2 | | 16.59 | 39.19 |
| 19 | 14 | | | | | | | | 29.77 |
| 20 | 14 | | 9.11 | 0.898 | 37.25 | | 113.02 | 16.91 | 20.33 |
| 21 | 15 | | | | | | | | 10.88 |
| 22 | 15 | 23.56 | 8.97 | | | | 113.03 | 17.24 | 1.43 |
| 23 | 16 | | | | | | | | 351.97 |
| 24 | 16 | | 8.84 | | | | | 17.59 | 342.50 |
| 25 | 17 | | | | | | | | 333.02 |
| 26 | 17 | | 8.71 | | 38.14 | | | 17.94 | 323.54 |
| 27 | 18 | | | | | | | | 314.05 |
| 28 | 18 | | 8.59 | | | 4.5 | | 18.32 | 304.55 |
| 29 | 19 | | | | | | | | 295.04 |
| 30 | 19 | 24.03 | 8.47 | | | | | | 285.53 |
| 31 | 20 | | | | | | | | 276.01 |
| June 1 | 20 | | 8.35 | | | | | 19.10 | 266.48 |
| 2 | 21 | | | | | | | | 256.95 |
| 3 | 21 | | 8.24 | 0.889 | 39.00 | | | 19.50 | 247.41 |
| 4 | 22 | | | | | | | | 237.86 |
| 5 | 22 | | 8.13 | | | | | 19.92 | 228.31 |
| 6 | 23 | | | | | | | | 218.75 |
| 7 | 23 | | 8.02 | | | 4.8 | | 20.34 | 209.18 |
| 8 | 24 | | | | | | | | 199.61 |
| 9 | 24 | 24.52 | 7.91 | | | | | 20.77 | 190.04 |
| 10 | 25 | | | | | | | | 180.45 |
| 11 | 25 | | 7.81 | | 39.54 | | | 21.21 | 170.87 |
| 12 | 26 | | | | | | | | 161.27 |
| 13 | 26 | | 7.71 | | | | | 21.66 | 151.67 |

*Defect of illumination in mm for a 42-mm diameter disk drawing.

| TD | MD | Declination ⊕, ° | Diameter, " | % Illuminated disk | Unilluminated disk, ° | Defect illumination* | Defect position ∠, ° | North Pole, ° | CM $0^h$ UT, ° |
|---|---|---|---|---|---|---|---|---|---|
| June 14 | 27 July | | | | | | | | 142.07 |
| 15 | 27 | | 7.62 | | | | | 22.11 | 132.46 |
| 16 | 28 | | | | | | | | 122.84 |
| 17 | 28 | | 7.53 | | | 4.9 | | 22.57 | 113.23 |
| 18 | 29 | | | | | | | | 103.60 |
| 19 | 29 | | 7.44 | | | | | 23.03 | 93.97 |
| 20 | 30 | | | | | | | | 84.34 |
| 21 | 30 | | 7.35 | | | | | 23.49 | 74.70 |
| 22 | 31 | | | | | | | | 65.06 |
| 23 | 31 | | 7.26 | | | | | 23.96 | 55.41 |
| 24 | 1 Aug. | | | | | | | | 45.76 |
| 25 | 1 | | 7.18 | | | | | 24.43 | 36.11 |
| 26 | 2 | | | | | | | | 26.45 |
| 27 | 2 | +25.01 | 7.10 | | 39.89 | 4.9 | 113.40 | 24.90 | 16.78 |
| 28 | 3 | | | | | | | | 7.11 |
| 29 | 3 | | 7.02 | | | | | 25.37 | 357.44 |
| 30 | 4 | | | | | | | | 347.77 |
| July 1 | 4 | | 6.95 | | | | | 25.84 | 338.09 |
| 2 | 5 | | | | | | | | 328.40 |
| 3 | 5 | | 6.87 | | | | | 26.31 | 318.72 |
| 4 | 6 | | | | | | | | 309.03 |
| 5 | 6 | | 6.80 | | | | | 26.78 | 299.33 |
| 6 | 7 | | | | | | | | 289.64 |
| 7 | 7 | 24.97 | 6.73 | | | 4.9 | | 27.25 | 279.94 |
| 8 | 8 | | | | | | | | 270.23 |
| 9 | 9 | | 6.67 | | | | | 27.71 | 260.53 |
| 10 | 9 | | | | | | | | 250.82 |
| 11 | 10 | | 6.60 | | 39.57 | | | 28.17 | 241.10 |
| 12 | 10 | | | | | | | | 231.39 |
| 13 | 11 | | 6.54 | | | | | 28.63 | 221.67 |
| 14 | 11 | | | | | | | | 211.95 |
| 15 | 12 | | 6.47 | | | | | 29.08 | 202.23 |
| 16 | 12 | | | | | | | | 192.50 |
| 17 | 13 | | 6.41 | | | 4.6 | | 29.52 | 182.77 |
| 18 | 13 | | | | | | | | 173.04 |
| 19 | 14 | 24.58 | 6.36 | | | | | 29.96 | 163.31 |
| 20 | 14 | | | | | | | | 153.57 |
| 21 | 15 | | 6.30 | | | | 113.02 | 30.39 | 143.84 |
| 22 | 15 | | | | | | | | 134.10 |
| 23 | 16 | | 6.24 | | 38.97 | | | 30.82 | 124.36 |
| 24 | 16 | | | | | | | | 114.61 |
| 25 | 17 | | 6.19 | | | | | 31.23 | 104.87 |
| 26 | 17 | | | | | | | | 95.12 |
| 27 | 18 | | 6.14 | 0.890 | | 3.8 | | 31.64 | 85.37 |
| 28 | 19 | | | | | | | | 75.62 |
| Aug. 7 | 24 | 23.10 | 5.89 | 0.894 | 38.00 | | 112.17 | 33.50 | 338.02 |
| 25 | 3 Sept. | 20.80 | 5.53 | 0.903 | 36.29 | | 110.48 | 35.98 | 162.08 |
| Oct. 12 | 30 Oct. | 9.57 | 4.87 | 0.931 | 30.16 | | 101.23 | 34.37 | 52.56 |

*Defect of illumination in mm for a 42-mm diameter disk drawing.

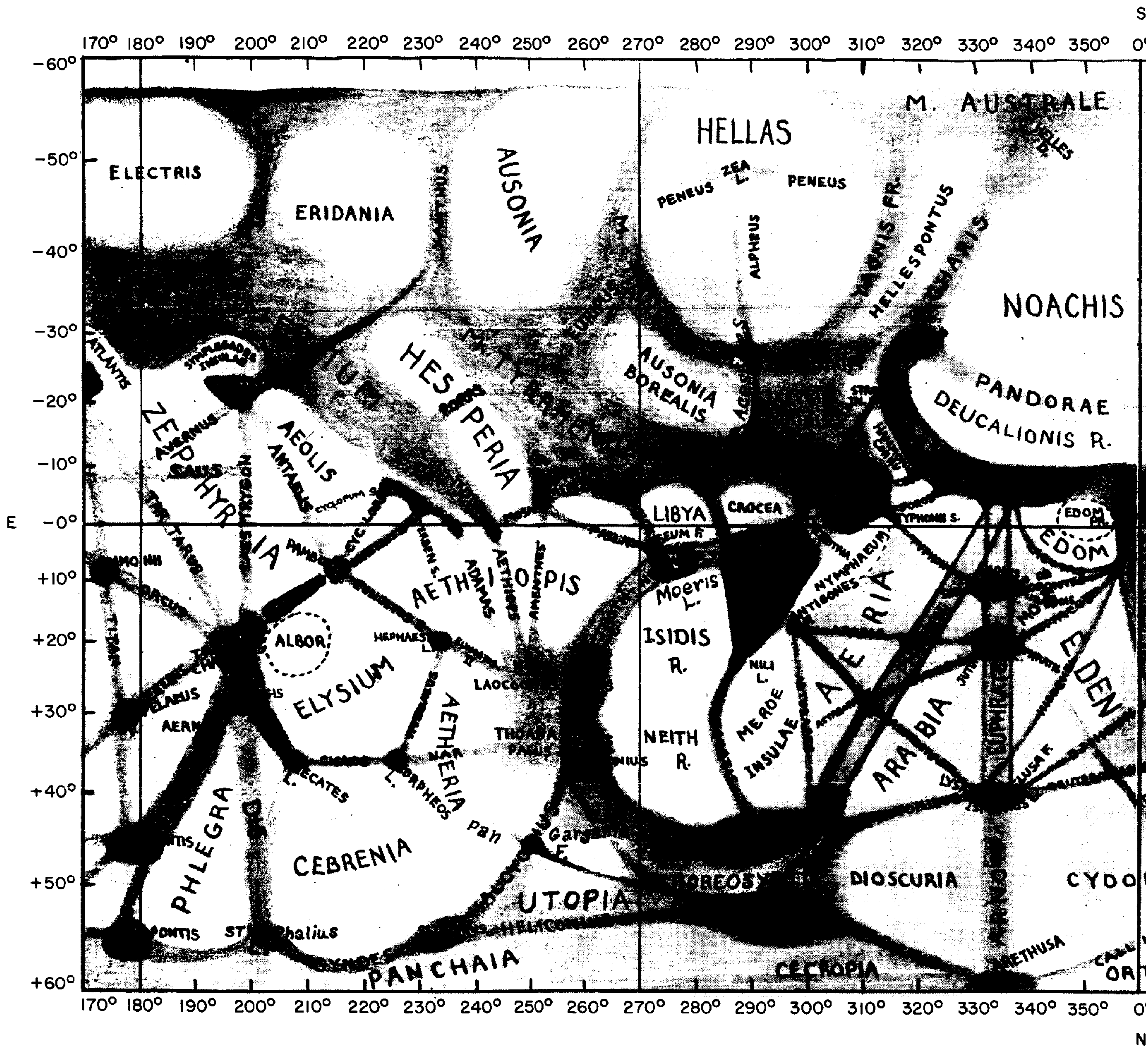
# APPENDIX C

## Change in Martian Longitude vs Universal Time

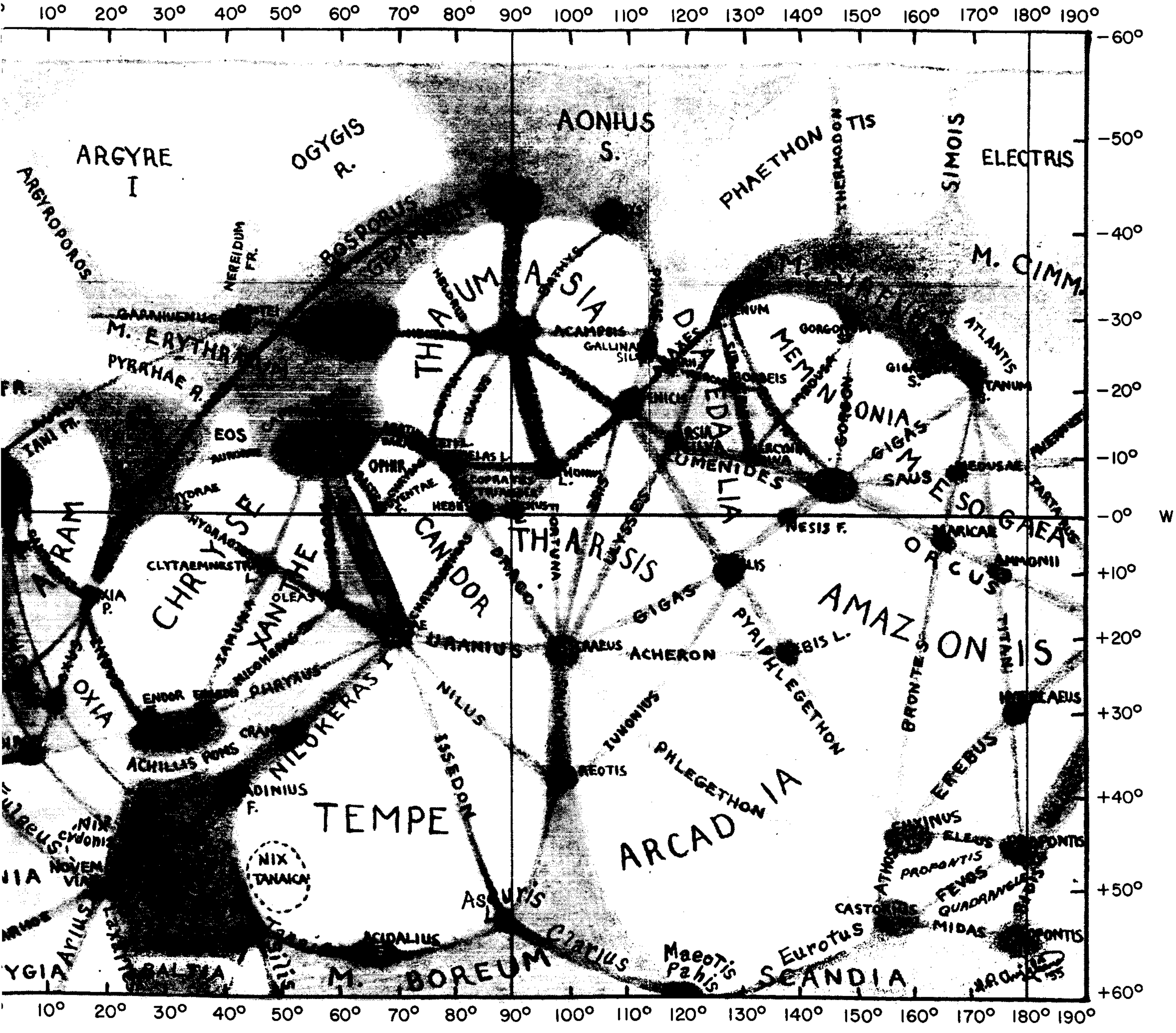
| UT | Mars CM correction, ° | UT | Mars CM correction, ° | UT | Mars CM correction, ° |
|---|---|---|---|---|---|
| $0^h\,00^m$ | 0.0 | $5^h\,00^m$ | 73.1 | $10^h\,00^m$ | 146.2 |
| 10 | 2.4 | 10 | 75.5 | 10 | 148.7 |
| 20 | 4.9 | 20 | 78.0 | 20 | 151.1 |
| 30 | 7.3 | 30 | 80.4 | 30 | 153.5 |
| 40 | 9.7 | 40 | 82.9 | 40 | 156.0 |
| 50 | 12.2 | 50 | 85.3 | 50 | 158.4 |
| $1^h\,00^m$ | 14.6 | $6^h\,00^m$ | 87.7 | $11^h\,00^m$ | 160.8 |
| 10 | 17.1 | 10 | 90.2 | 10 | 163.3 |
| 20 | 19.5 | 20 | 92.6 | 20 | 165.7 |
| 30 | 21.9 | 30 | 95.0 | 30 | 168.2 |
| 40 | 24.4 | 40 | 97.5 | 40 | 170.6 |
| 50 | 26.8 | 50 | 99.9 | 50 | 173.0 |
| $2^h\,00^m$ | 29.2 | $7^h\,00^m$ | 102.4 | $12^h\,00^m$ | 175.5 |
| 10 | 31.7 | 10 | 104.8 | 10 | 177.9 |
| 20 | 34.1 | 20 | 107.2 | 20 | 180.3 |
| 30 | 36.6 | 30 | 109.7 | 30 | 182.8 |
| 40 | 39.0 | 40 | 112.1 | 40 | 185.2 |
| 50 | 41.4 | 50 | 114.5 | 50 | 187.6 |
| $3^h\,00^m$ | 43.9 | $8^h\,00^m$ | 117.0 | $13^h\,00^m$ | 190.1 |
| 10 | 46.3 | 10 | 119.4 | $14^h\,00^m$ | 204.7 |
| 20 | 48.7 | 20 | 121.8 | $15^h\,00^m$ | 219.3 |
| 30 | 51.2 | 30 | 124.3 | $16^h\,00^m$ | 233.9 |
| 40 | 53.6 | 40 | 126.7 | $17^h\,00^m$ | 248.5 |
| 50 | 56.0 | 50 | 129.2 | $18^h\,00^m$ | 263.1 |
| $4^h\,00^m$ | 58.5 | $9^h\,00^m$ | 131.6 | $19^h\,00^m$ | 277.8 |
| 10 | 60.9 | 10 | 134.0 | $20^h\,00^m$ | 292.4 |
| 20 | 63.4 | 20 | 136.5 | $21^h\,00^m$ | 307.0 |
| 30 | 65.8 | 30 | 138.9 | $22^h\,00^m$ | 321.6 |
| 40 | 68.2 | 40 | 141.3 | $23^h\,00^m$ | 336.2 |
| 50 | 70.7 | 50 | 143.8 | | |

# Index of Areographic Names

Names in italics are alternate names for the preceding feature. Numbers enclosed within parentheses are the longitude and latitude of the feature, in that sequence, and they refer to the Mars–key map on the last page of this Report. Numbers *not* enclosed within parentheses are page numbers.


S
N
E
170° 180° 190° 200° 210° 220° 230° 240° 250° 260° 270° 280° 290° 300° 310° 320° 330° 340° 350° 0°
-60° -50° -40° -30° -20° -10° -0° +10° +20° +30° +40° +50° +60°
M. AUSTRALE
HELLAS
ELECTRIS
ERIDANIA
AUSONIA
PENEUS
ZEA L.
ALPHEUS
HELLESPONTUS
NOACHIS
ATLANTIS
SYMPLEGADES INSULAE
HESPERIA
AUSONIA BOREALIS
PANDORAE
DEUCALIONIS R.
ZEPHYRIA
AEOLIS
AVERNUS
SALIS
ANTAEUS
CYCLOPUM S.
LIBYA
CROCEA
TYPHONII S.
EDOM
AETHIOPIS
ADAMAS
AETHIOPS
AMENTHES
Moeris L.
NYMPHAEUM
ANTIGONES
ISIDIS R.
ALBOR
HEPHAESTUS L.
ELYSIUM
NILI L.
LAOCOON
AETHERIA
THOANA PALUS
NEITH R.
MEROE INSULAE
ARABIA
EDEN
EUPHRATES
HECATES L.
ORPHEOS
Pan
Gargantua F.
PHLEGRA
CEBRENIA
UTOPIA
DIOSCURIA
CYDO
Phalius
PANCHAIA
CECROPIA
ARETHUSA

187-1




Mars—key map (courtesy Association of Lunar and Planetary Observers); modified for 1964–1965 apparition